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June, 1940

JUN 6 1940

Heating · Piping and Air Conditioning

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Page 375

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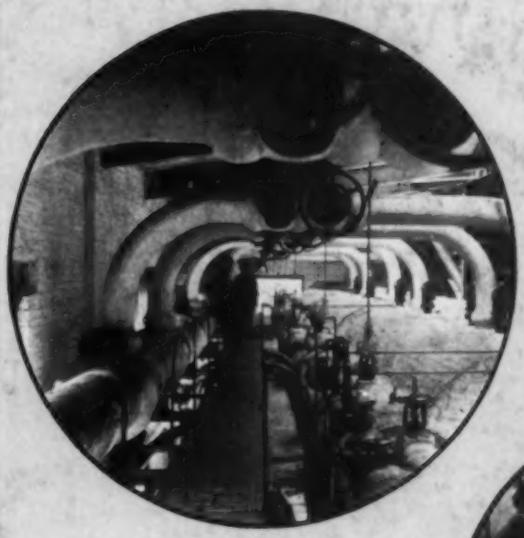
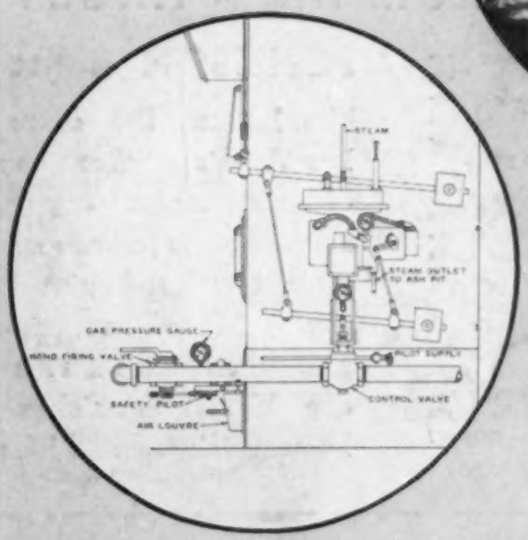


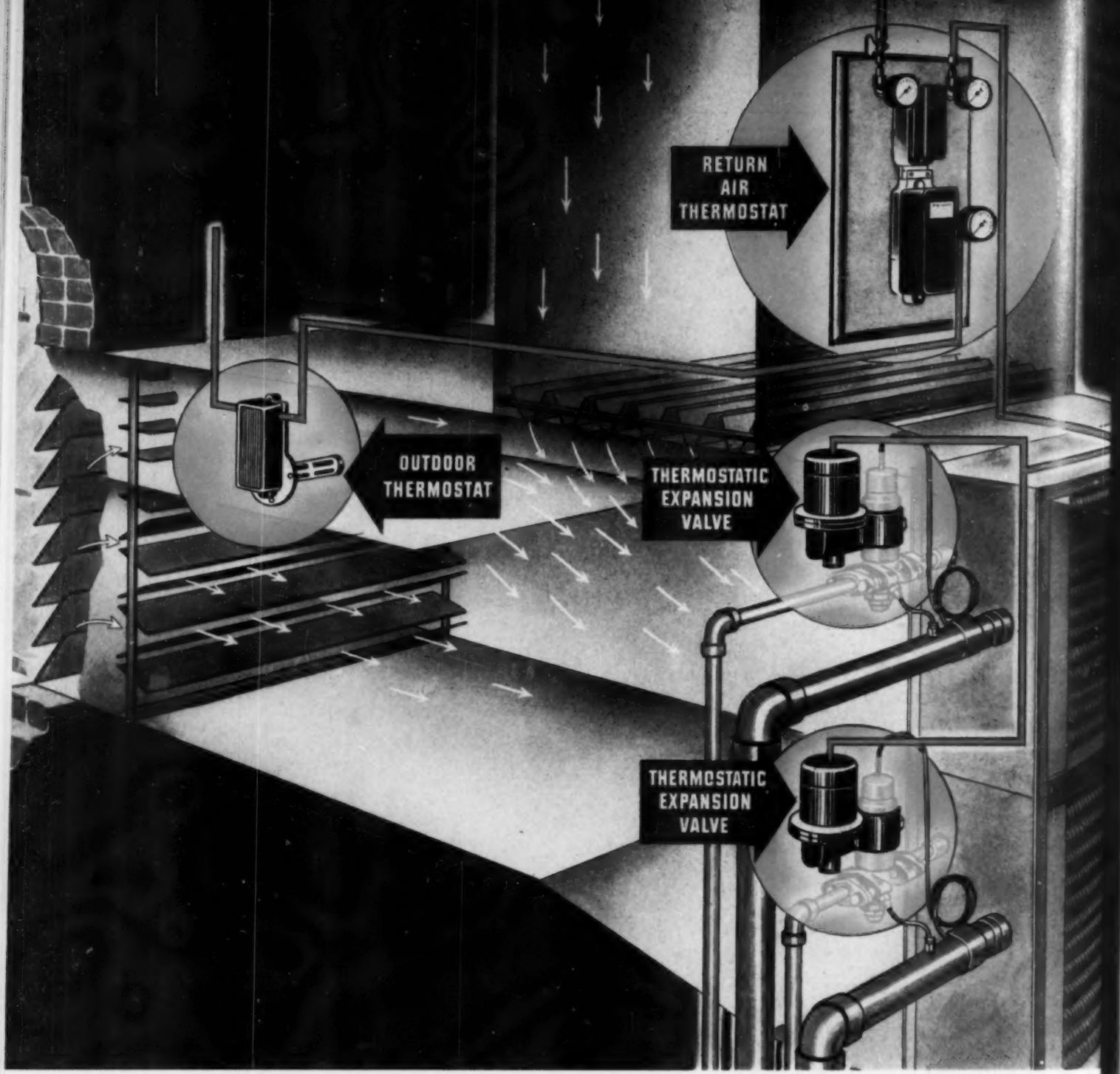
THIRTY YEARS' experience with a steam main (left) is described by W. H. Wilson, who helped install it, has "lived with it" ever since, page 348

HOTEL WEEK, June 2-8, is marked by an article by Warren D. Lewis, chief engineer of the New Yorker, page 343. The hotel restaurant is an important application



GAS BURNER application to boilers and control is the subject discussed by L. S. Reagan, page 362

MANY MORE — These are but three of this month's articles. Others include F. E. Giesecke on radiant heating; air raid shelter ventilation, by Thomas C. Angus; piping drafting, by Albert Jorgensen; and others



CONTROL INSTRUMENTS RESET AUTOMATICALLY

RETURN AIR THERMOSTAT, in the hook-up suggested above, senses the temperature of the air which is recirculated from the conditioned space. The temperature setting of this Remotely Adjusted Thermostat is reset automatically to maintain a required relationship with the temperature at some remote point.

OUTDOOR THERMOSTAT, in this particular case, automatically resets the Return Air Thermostat. This illustrates the use of Johnson remotely adjusted instruments in summer cooling, for example, where a given differential between outdoor and indoor temperatures is desired.

THERMOSTATIC EXPANSION VALVES, supplying refrigerant to direct expansion coils, are fitted with Johnson Modulating Attachments. The remotely adjusted Return Air Thermostat throttles the supply of refrigerant to conform to the cooling load conditions as reflected by the temperature in the recirculating duct. An exclusive Johnson feature!

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The Johnson line of remotely adjusted thermostats and humidostats satisfies one more of the definite requirements of the air conditioning and allied industries. This group of instruments is just one more evidence of the ingenious development work and unique design which characterize all of the devices in modern Johnson temperature control systems. The particular application illustrated above may suggest solutions of problems with which *you* have been confronted. Ask for bulletins which describe Johnson remotely adjusted instruments.

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CONTENTS *for* JUNE, 1940

Volume 12 — Number 6

Hotel Air Conditioning, by Warren D. Lewis 343

More Air Conditioning for Gold Mines, by James A. Bentley 347

Practical Piping Problems—Thirty Years' Experience With a Steam Main, by W. H. Wilson 348

Panel Heating Construction 350

Types of Drawings Used in Power Piping Drafting, by Albert Jorgensen 351

Ventilation of Air Raid Shelters, by Thomas C. Angus 356

Radiant Heating and Cooling, by F. E. Giesecke 357

Vertical Conversion Gas Burners, by L. S. Reagan 362

The Psychrometric Chart—Its Application and Theory, by William Goodman 367

Better Product by Air Conditioning, by O. F. Gilliam 370

District Heating Association Holds Meeting at French Lick 372

Properties of Mixtures of Air and Saturated Water Vapor for Barometric Pressures from 22 In. to 32 In. of Mercury, by William Goodman 373

The Editor's Pages (front section) 43

Equipment Developments (back section) 112

Booklets, Reports and Papers (back section) 120

Book Reviews (back section) 121

Conventions and Expositions (back section) 123

Recent Trade Literature (back section) 125

Index to Advertisers (back section) 132

Journal Section of the American Society of Heating and Ventilating Engineers

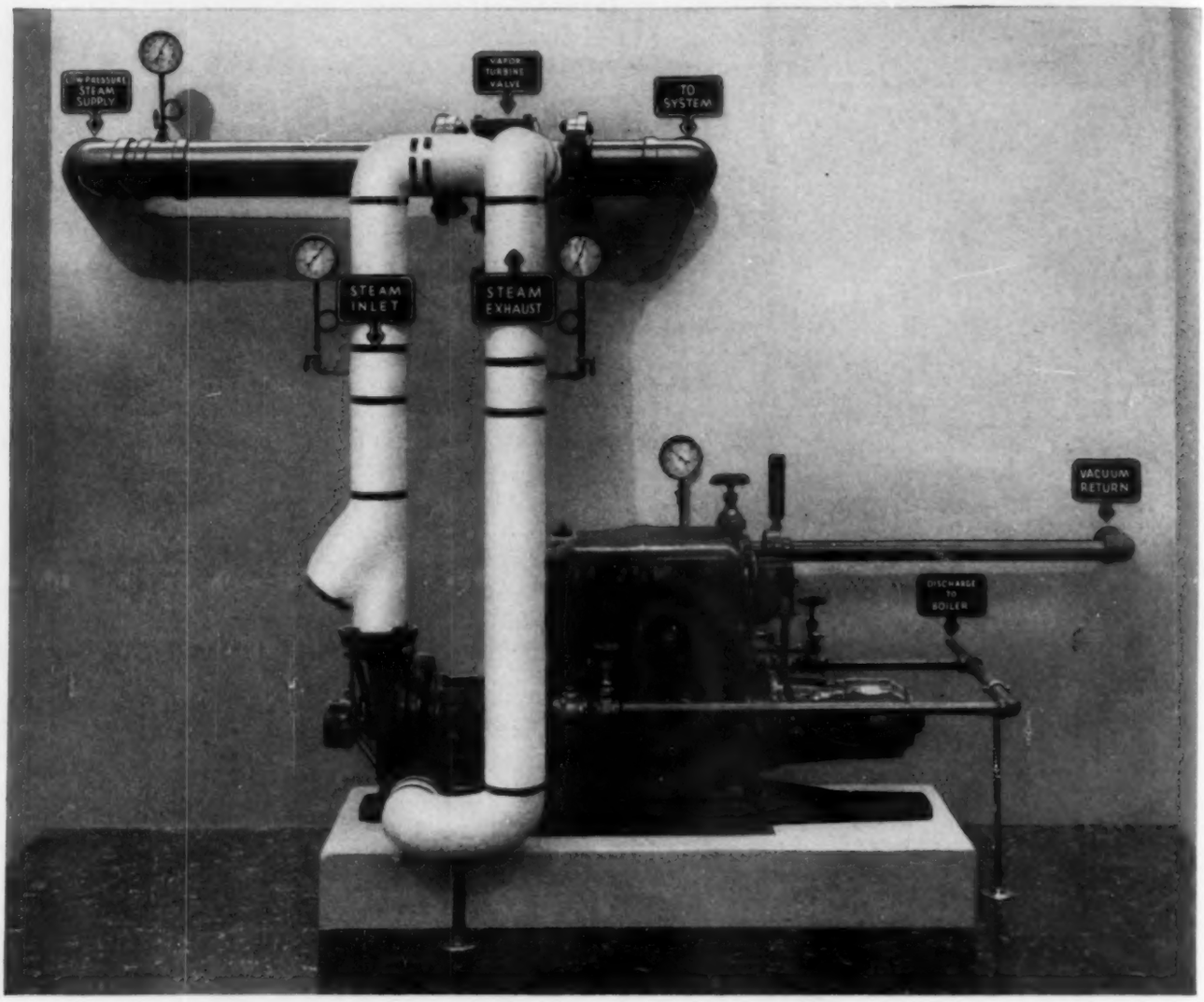
Study of Changes in the Temperature and Water Vapor Content of Respired Air in the Nasal Cavity, by Lauren E. Seeley 377

Dirt Patterns on Walls, by R. A. Nielsen 389

Applications of Gas to Air Conditioning, by George E. May 395

Bulletin Section 398

Where Heat Must Not Fail— Install this SAFE Heating Pump!



In Hospitals, Greenhouses, Schools, Public Buildings, Theatres, wherever heating systems must not fail, install the Nash Vapor Turbine, for it is independent of electric current failure, and continues to operate as long as there is steam in the system.

This is because the prime motive power of this economical pump is a special steam turbine, controlled by a unique "Vapor Turbine Valve", which automatically bypasses from the heating main a small portion of steam, the exact amount necessary to develop the power needed to remove the condensate and maintain the required vacuum on the system. Even this small amount is passed immediately back to the mains, and goes on to the system with little heat loss. This pump operates on any system, high or low pressure.

The Vapor Turbine is a most economical pump, for the elimination of electric current does away with current cost, the largest single item in the operation of an ordinary return line heating pump. Bulletin on request.

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THE EDITOR'S PAGES

REPORT AIR CONDITIONING ACTIVITY

There appeared on these pages last month a report for a number of cities on the number and capacity of air conditioning installations during the first quarter of this year as compared with the first quarter of 1939. The figures were obtained through the courtesy of the electric utilities serving the various cities for which information was presented. Totalling the definite horsepower figures for the cities listed in the May HPAC indicated a 20 per cent increase for the first quarter of 1940 over the first quarter of 1939.

The following paragraphs give additional information on other areas (not presented in May as the data were received too late for last month's issue):

Beaumont, Texas—The first part of 1940 appears to be at least 50 per cent ahead of the same 1939 period, with more activity especially in the smaller store units and residential units. One department store is building a modern three story structure that will be completely air conditioned although actual operation will not start until 1941. The connected load for this installation will be around 230 hp.

El Paso, Texas—No large installations in prospect right now although a few smaller jobs are pending. Evaporative cooler business quite active and may exceed last year slightly.

Hagerstown, Md.—Three air conditioning installations totalling 104 hp added to lines of Potomac Edison system the first quarter of 1940 compared with one 1 hp job in same 1939 period. Five installations totalling 44 hp in month of April, with prospects for rest of year most encouraging.

Indianapolis, Ind.—Four installations with total connected load of 135.75 hp for first quarter of 1940 compared with three installations and 16 hp in 1939. Prospects for balance of 1940 definitely are substantially better than 1939 although not in proportion to the figures for the first quarter. Theaters and stores appear to be the best buyers.

Oklahoma City, Okla.—Air conditioning activity running well ahead of last year with installations sold showing an increase of 75 per cent and horsepower an increase of 3 per cent (because of the lower average horsepower per installation). Jobs closed in April and negotiations pending indicate that a more substantial lead in horsepower can be expected. Evaporative cooling getting a big play.

Philadelphia, Pa.—Thirty-three installations and 1006.7 hp for first quarter of 1940 compared with 26 installations and 1408.8 hp for first quarter of 1939. It is believed over-all sales volume for 1940 will be somewhat less than 1939, although a larger volume of business in store coolers and portable units is anticipated.

Richmond, Va.—Six installations totalling 102 hp for first quarter of 1940 compared with eight installations totalling 203 hp for 1939 first quarter.

Springfield, Mass.—Although no sales are reported for the first quarter of 1940 and while the same period of 1939 ran up a total of 105 hp, the prospects for the summer months are much more encouraging and it is believed the year will end up with a total equal to 1939.

St. Paul, Minn.—Based on requests to provide electric service capacity, the records show one installation of 10 hp during first four months of 1939. For a similar period in 1940 seven installations totalling approximately 100 hp are reported. New air cooling business is greatly dependent upon when hot weather season begins, and so far this year weather conditions have been such as to discourage air cooling business, although that may change very quickly.

Syracuse, N. Y.—Five installations totalling 50 hp for first quarter of 1940 compared with five jobs totalling 32.75 hp in 1939. The present indications are that 1940 installations will exceed those in 1939, with majority of them in stores.

LAUER HEADS ACMA

Stewart E. Lauer, York Ice Machinery Corp., was elected president of the Air Conditioning Manufacturers' Association May 11 during the annual meeting at Hot Springs, Va. Other officers are vice-president, Stuart M. Crocker, General Electric Co., and treasurer, P. A. McKittrick, Parks-Cramer Co.

The ACMA board of directors comprises, in addition to the officers, chairman, P. Y. Danley, Westinghouse Electric & Mfg. Co.; vice-chairman, E. T. Murphy, Carrier Corp.; J. M. Fernald, Baker Ice Machine Co., Inc.; F. D. Kirk, Vilter Mfg. Co.; and H. R. Sewell, B. F. Sturtevant Co.

JOHN HOWATT REVIEWS CHICAGO SCHOOL HISTORY

Marking his 27th year as chief engineer of the Chicago board of education, John Howatt has prepared a 70 p. booklet of Notes on the First One Hundred Years of Chicago School History, printed by the Washburne trade school press. Mr. Howatt gathered the data from records of the Chicago historical society, the Chicago public library, the board of education and through personal interviews and experiences. The facts are presented in chronological order with no pretense on the part of the author that they cover the complete history.

Mr. Howatt's book makes interesting reading, particularly to those concerned with the heating and ventilation of school buildings. In a list of "Chicago board of education firsts" the date of the introduction of mechanical ventilation for schools is given as 1868, the first chief engineer was appointed in 1885, coal was first bought on a Btu basis in 1912, and 1920 was the first year in which the coal bill exceeded a million dollars.

Mr. Howatt's book is not generally available but copies have been placed in the Chicago library and the schools.

STANDARDIZATION PROGRAM FOR FANS

Recent action by the National Association of Fan Manufacturers will bring the advantages of industry standardization to all users of fans as applied by architects and engineers, or as individually purchased, the association believes. The scope of the standardization program, as presented at the recent NAFM annual meeting, covers those types of centrifugal fans designed for application in, and furnished under specifications for, heating, ventilating and air conditioning.

The standards were established for 25 sizes of fans by setting up a series of maximum wheel diameters between the limits of 1 to 11 ft, and their corresponding maximum outlet areas for both single and double width types. The series of wheel diameters was based on the preferred number system advocated by the American Standards Association.

The standardization program was approved to become effective the early part of 1941.

WORLD'S FAIR MOVIE SHOWS STEEL MAKING

An air conditioned moving picture theater has been added to the United States Steel Subsidiaries exhibit at the New York World's Fair in order to make possible the presentation of the technicolor movie Men Make Steel.

Men Make Steel was filmed by a Hollywood crew. The equipment, direction and technique are the same as are used in making a feature production. The actors, however, are the

An air conditioned movie theater has been added to the United States Steel Subsidiaries exhibit at the New York World's Fair. Home of the exhibit is this steel hemisphere turned "inside out," with the supporting trusses forming part of the exterior of the unusual building

men who make steel and the scenes are scenes of actual steel operations photographed at the ore mines and inside the mills where steel is made and rolled into finished forms. The accompanying narrative is presented by Edwin C. Hill.

MINERAL WOOL INDUSTRY CELEBRATES CENTENNIAL

The National Mineral Wool Association, whose offices are at 1270 Sixth Ave., New York, N. Y., celebrated the centennial of the mineral wool industry at a meeting in Chicago May 16. The technical session, under the chairmanship of Jan S. Irvine, head of the association's technical committee, included papers on research and the development of an industry, by Frank B. Rowley; current problems in study of condensation, by L. V. Teesdale; tests of insulation in the Research Residence, by S. Konzo; insulation and low cost housing, by Woodruff H. Purnell; effect of higher interior wall surface temperatures on economy and comfort, by F. E. Giesecke; futility of the law of diminishing returns as applied to insulation, by W. T. Miller; determining minimum requirements for insulation, by Robert K. Thulman; and mortgage lender's interest in adequate insulation, by G. Hicks Fallin. The centennial banquet was held under the chairmanship of James R. Addington, president of the association.

In his introductory remarks, Mr. Irvine said that the meeting was the largest gathering that the association had ever had. Mr. Irvine mentioned also that the United States could save enough in fuel conservation by insulating every building that needs insulating to pay for the defense program which President Roosevelt had requested congress to legislate.

JAMES D. FLEMING APPOINTED

James D. Fleming has been appointed vice-president and sales manager of Grinnell Co., Inc. Previous to this appointment, Mr. Fleming was vice-president and manager of the Grinnell Co. of the Pacific, a subsidiary. He will continue to manage the Pacific company but will be located at the Providence, R. I., home office.

STANDARDIZE COIL RATING AND TESTING

Engineers from many of the manufacturers of blast surfaces for heating and cooling met at the Statler Hotel in Detroit on April 10 for the purpose of discussing and considering a standardized method for testing and rating their product. The meeting was followed the next day by a conference of the executives of the companies, at which time the Blast Coil Manufacturers' Institute was formed. The officers of the new association are R. J. Resch, McQuay, Inc., president; R. M. Stikeleather, B. F. Sturtevant Co., vice-president; and M. F. May, Young Radiator Co., secretary-treasurer.

The primary purpose of the institute is to develop and establish a standard method of testing and rating blast coils for heating and cooling.

EXTENDS FAIR EXHIBIT AIR CONDITIONING

Relief from the heat of summer will be offered visitors to the General Motors highways and horizons building at the New York World's Fair this season by means of additional air conditioning equipment which has been extended to serve the entire exhibit area of the huge display. The new equipment provides for an increase of almost 300 tons in refrigeration capacity over that installed last year.

The largest of the new areas to be conditioned is the automotive exhibit.

RADIATOR HEAT TO BE STUDIED

The Institute of Boiler and Radiator Manufacturers, 60 E. 42nd St., New York, N. Y., has announced the signing of a contract with the University of Illinois for the construction and operation of a research house at Urbana, Ill., in the interests of radiator heat. Fourteen of the members of the institute, who are manufacturers of cast iron boilers and radiators, have subscribed a total of $50,000 to cover the cost of constructing and equipping the house and assuring its operation for a minimum period of three years.

Purpose of this research program is to study the factors having to do with the installation, operation and maintenance of various types of heating systems, and to study the factors pertaining to the atmospheric environment produced and maintained.

HOT WEATHER CUTS RETAIL SALES

Statistics reveal that hot weather sales in stores, shops, movies, restaurants, etc., are approximately 27 per cent less than the average for the rest of the year, according to "Profit Topics," a bulletin on "stepping up earnings with electricity" which is issued regularly by the Oklahoma Gas and Electric Co. This sales loss is directly attributed to the discomfort of shopping, eating and moving around on hot days. It means that the summer slump takes approximately 27 cents out of every potential dollar's worth of business from establishments that do not have air conditioning. Firms which have installed air conditioning invariably report summer sales increases that wipe out the customary decrease.

An informative department in "Profit Topics" is entitled "Thru Gray Eyes." It comprises interesting items on air conditioning written by Earle W. Gray, who is in charge of Oklahoma Gas and Electric's air conditioning department.

POWER SHOW DATES ANNOUNCED

The 14th National Exposition of Power & Mechanical Engineering has recently been announced for December 2 to 7, 1940, at Grand Central Palace, New York, N. Y. Better known as the National Power Show, this biennial exposition brings together the product displays of over 300 leading manufacturers serving the power and allied fields.

Hotel Air Conditioning

Warren D. Lewis, Chief Engineer of the Hotel New Yorker, explains some of its advantages and gives practical suggestions for design

THE history of hotel air conditioning is founded on the attempt of hotel managers to add another service for the comfort of their guests; the success of the National Hotel Management Co. was largely built around unusual services to the guests of the various hotels under its supervision. Among these services was air conditioning, and our late president, Ralph Hitz, was one of the first to recognize its possibilities and adopt it for hotels under his management as they were acquired.

Now, lest I be misunderstood, I would like to state that the reasons behind the adoption of air conditioning to hotel operation were economic rather than philanthropic. Air conditioning has been used to attract patrons and to help hold them.

Restaurant a Logical Beginning

The most logical place to find air conditioning in a hotel is in the restaurant. Hotel managers early recognized the advantage to be gained by providing diners with a cool, comfortable place to eat as under these conditions guests will take their time and spend more for food than in a stuffy atmosphere of food smells and odors. Then again, hot food and drinks add to the temperature of the room, which may become warmer than outdoors if not air conditioned—especially during busy hours.

It was usually part of our procedure in taking over the management of a hotel to plan as one of the first improvements the air conditioning of the restaurants if they were not already so equipped. One hotel thus taken over had a dining room above the hotel laundry and this room could not be used except during the winter months as it was impossible at other times to keep the temperature at a reasonable figure. The room was air conditioned, opened as a formal dining room and became one of the most popular in New York City. A similar room in a southern hotel was air conditioned and was enabled to do a year 'round business, although dancing during the summer months would have been anything but a pleasant pastime without the conditioning. The coffee shop in the Hotel New Yorker is an interior room, one story below the street level, and is ventilated by long air ducts exposed to heat pick-up. During the summer months this restaurant would be so warm without air conditioning that it is doubtful if it would attract very much business.

Ballrooms Next in Importance

Ballrooms and private dining rooms are next in importance and where possible were also air conditioned in hotels where this service was lacking. Air conditioning is a great help to the hotel sales department in selling banquets and dances during the warm months, as committees are learning the many advantages and comforts of an air conditioned room. Any increase in the use of these rooms on account of air conditioning is clear gain, as the rooms are a total loss when idle and anything which promotes their use is worthwhile.

Great care must be taken in ventilating ballrooms and dining rooms to avoid drafts; it is surprising how noticeable a slight draft is to a diner or dancer. A perfectly ventilated room is the first requisite for a satisfactory air conditioning installation and complaints of this nature are the first concern of the engineer when a new room is opened to the public. Smoke exhaust, as it is called, or additional exhaust for any formal dining room or ballroom, is highly desirable and should consist of a separate fan unit as it is only used in cases of high smoke concentrations, or as additional exhaust, and discharges to the atmosphere. Operating two or more large rooms from one air conditioning system, especially if the same ventilating fans are used, is a hazard to be avoided in the original installation and conditions of this kind have caused the writer a great deal of trouble in trying to obtain satisfactory temperatures in the affected rooms.

Summary of
Hotel Air Conditioning

By Warren D. Lewis

Because June 2-8 is being celebrated as National Hotel Week, it is particularly appropriate that our lead-off presentation this month be devoted to hotel air conditioning. It is fortunate, too, that we could get Mr. Lewis to prepare it, for he has an intimate and wide experience with his subject. . . . . In this article, the first of two, it is pointed out that the reasons for air conditioning a hotel are economic and are in line with the hotel policy of giving its guests every service. The most logical place to find air conditioning in the hotel is in the restaurant, for with a cool and comfortable place to eat patrons will take their time and spend more for food than in a hot, stuffy atmosphere. Ballrooms and private dining rooms are next in importance and air conditioning is a great help to hotel sales departments in selling banquets and dances in the summer months; any increase in the use of these rooms on account of air conditioning represents clear gain. Great care must be taken to avoid drafts in such spaces, for it is surprising how noticeable a slight draft is to a diner or dancer. As to lobbies, Mr. Lewis is not personally in favor of air conditioning them in a commercial hotel because stack effect makes it difficult to hold the cool air there, and because it is likely to make the lobby a "hang-out," to the detriment of the guests. . . . . The problem today is to supply real air conditioning, and this means better temperature and humidity control than used a few years ago. Hotel guests are critical to the *n*th degree, and a draft or too high or low a temperature results in many complaints. Cleaning the air is a problem in hotel air conditioning. . . . . After giving attention to operation and maintenance, including the use of recording instruments to assist in operation, Mr. Lewis discusses the regulations of New York City regarding the use of water conserving equipment and indicates how they may affect the location of the refrigerating equipment. He feels there are advantages in installing the equipment on the roof, circulating low temperature brine in a loop system to the lower floors. . . . . A second article by Mr. Lewis will be devoted to methods of hotel bedroom air conditioning

Lobby Air Conditioning

Nothing has been said so far about lobby air conditioning and the writer personally is not in favor of it in a commercial hotel for two reasons. First, it is apt to be quite an expense to install if the lobby is at all large and the hotel is high, as the stack effect will make it difficult to hold the cold air in the lobby proper; second, it is apt to make the lobby a "hang-out," to the detriment of the guests. The lobby of the Hotel New Yorker was never air conditioned and due to the stack effect of the building would present a problem and take an excessive tonnage to handle. The same can be said about stairways in tall hotels as the stack effect will likewise clear out the cool air in a short time if not continuously supplied.

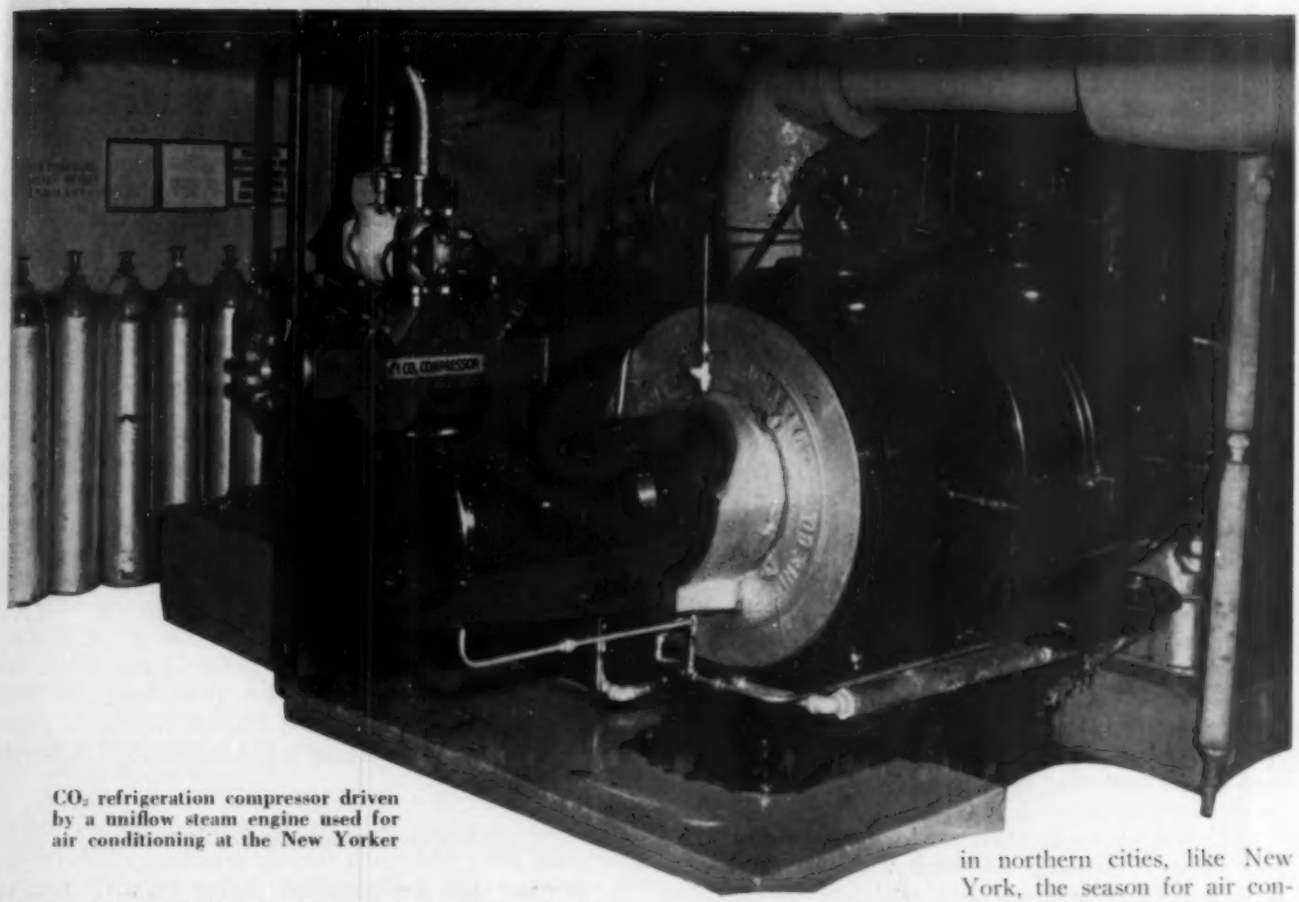
The Hotel New Yorker, as originally erected, had its four public dining rooms air conditioned, as well as the ballrooms and private dining rooms on the second, third and fourth floors. The lobby was not air conditioned (and probably never will be) and no thought was given to air conditioning any of the guest rooms at that time as this type of air conditioning had not come to be a factor in hotel operation. The designers did not appreciate the value of air conditioning and later on it was necessary to add to the capacity and make other improvements in line with the management's policy to give the public "more than it asked for." It was originally intended to keep the doors to the dining rooms open, but this did not work out as expected and in very hot weather especially the doors had to be closed.

Importance of Control and Filters

The various systems were also designed to operate at a constant room temperature, regardless of the outdoor temperature. A decade ago, when the New Yorker opened, the public was not as accustomed to real air conditioning as it is now and the tendency was to cool everyone off regardless, as many can remember with the theaters where the signs outside advertised "70 degrees inside" *and meant it*. Today the problem is to supply real air conditioning—and not just cold air—and this means far better temperature and humidity control than used a few years ago; in fact, an air conditioning system is not "good" without good control.

Ventilation and air conditioning in hotels is much more exacting than in office buildings or department stores. Hotel patrons are critical to the *n*th degree, and any slight draft, too high or too low a room temperature (in the opinion of the guest), etc., brings forth numerous complaints. Complaints from guests are more or less encouraged by hotel managers; for example, in our own hotels it has always been the policy of the management to encourage suggestions and criticisms—all of course with the object of improving the service rendered the guest.

One of the greatest difficulties in operating air conditioning as well as ventilating systems is to actually *clean* the air and remove all the dust. Except for the new



CO_2 refrigeration compressor driven by a uniflow steam engine used for air conditioning at the New Yorker

electrostatic methods, air cleaning is usually not absolutely entirely effective as is evidenced by the smudge on a ceiling if there is a supply air grille on the wall just below it. Air washers will remove a great deal of the dirt, principally the heavier particles, but the fine and greasy particles go right on through. Installing dry type filters ahead of the air washer has been advocated, but the writer can see no objection to placing the filters between the supply fan suction and the air washer where they receive the mixture of freshly conditioned and recirculated air. In this location the filters are not subject to such high dust concentrations and their useful life should be considerably greater. In addition, they are not subject to excessive moisture and even rain where the filter bank is partly exposed to the elements, which is a too frequent condition in crowded installations.

One Installation Forces Others

Hotels in the South and those in cities like Cincinnati or St. Louis where the humidity also is very high have more reason to install air conditioning than in northern cities which have a shorter season of hot weather as the guests will gladly pay extra for it especially if they come from the cooler sections of the country. After all, the economic side of the question is most important as in the end there must be additional revenue to warrant the investment. Therefore, the long spells of *hot* weather in the South give this part of the country an economic advantage in installing air conditioning. In Dallas, for example, very small restaurants and shops find it profitable to air condition, to say nothing of the department stores and theaters where it is quite commonplace. But in northern cities, like New York, the season for air conditioning is nowhere near as long and it is apt to be treated by many people as somewhat of a luxury, and consequently its economic importance is less. There have been a number of cases where the installation of air conditioning in one hotel in a community has forced the other hotels in the same city to do likewise; in fact, every time we made another air conditioning installation in one particular hotel we were operating our principal competitor duplicated it in his hotel.

Use of Instruments

In a large hotel it is necessary to assign a man to ventilation whose duty it is not only to maintain proper conditions in all the dining rooms and ballrooms and keep a record of temperatures, but also to maintain in proper order the air washers, pumps, thermostatic controls, etc., which are scattered around the building and not under the supervision of the watch engineer in the basement. A plentiful supply of thermometers on the various washers, air ducts, etc., is a necessity. In the Hotel New Yorker, a recording thermometer is installed in the engine room to register the outdoor temperature and, incidentally, to show the engineer which way the temperature is going (up or down) so he can schedule his refrigerating machines. There is also a recorder in the engine room showing the temperature in all the dining rooms, as well as the trend of the temperatures, and which assists in maintaining satisfactory conditions. Another instrument gives a complete 24 hr record of the temperature of the cooling water to and from the air washers. There are others, but these are the principal ones the engineer needs properly to operate the system.

No permanent wattmeters are installed on the motors of the various compressors, pumps, etc., but sufficient data are on hand to make up fairly accurate estimates of the electric current consumed and this largely determines the daily cost of air conditioning.

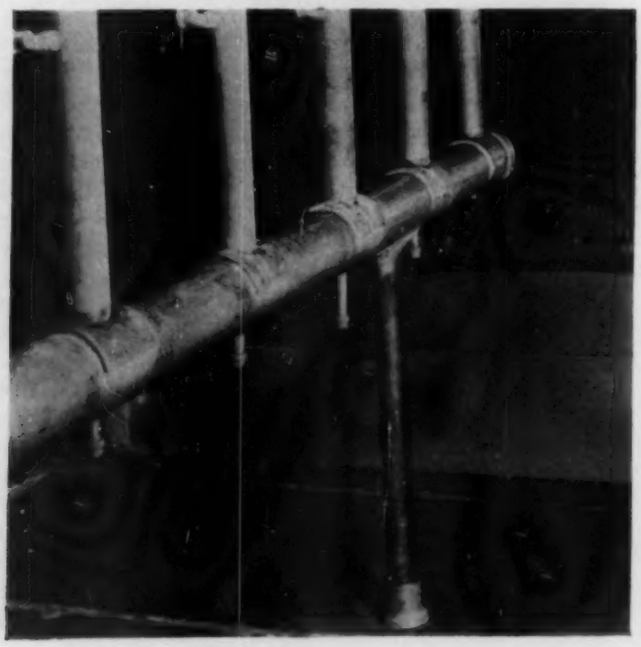
Location of Equipment

In installing refrigerating or air conditioning compressors, coolers, condensers, and other such equipment, the best location for them as a rule is in the basement under the personal supervision of the watch engineer. While this is not always possible, the writer is opposed to refrigerant lines "going upstairs," as a circulating cold water or brine line will do a better job in the long run and require less maintenance. The municipal authorities in New York City feel the same way, for running refrigerant lines from one floor level to another is prohibited.

To cut down on piping maintenance, we have used welded lines; at the New Yorker it has been found on both brine and cold water lines when leaks develop they are invariably in the threads of the pipes and fittings. The remedy we have adopted is to bend a section of pipe or use a welding fitting. Bent sections of pipe are often preferable as it is possible to replace several fittings with one bent piece which not only cuts down on the number of welds but may also result in more gradual bends and thus reduce pipe friction.

Corrosive action in piping and air washers has been kept down by treating the water with soda ash and a little lime to prevent any acid condition. Most of the trouble with our air washers has been due to the corroding of eliminator plates and louvers and leaks developing from a similar reason in the water tank or pan. In all cases, the eliminator plates and louvers have been replaced using 16 oz sheet copper. The washer tanks have been relined using 2½ lb sheet copper, but as these set on top of cork insulating pads, it was decided to try out monel metal because of its tougher nature as the cost of the material as well as the installation labor cost was approximately the same in both cases. Since then three more washer pans have been relined with monel metal, although copper is used entirely for louvers and eliminator plates.

Interior view of one of the large air washers at the New Yorker, showing the brass piping for the sprays and the monel metal pan. The top of the air washer above the pan, which was not replaced with monel, is kept tar coated to prevent corrosion. Note the brass pipe headers. Brass pads were sweated on top of the pipe before tapping for the uprights to give more body, says Mr. Lewis



For plants which use baudelot coolers for chilling water with CO_2 systems, the Hotel New Yorker has a somewhat novel installation which may be of interest. The baudelot cooler on the air conditioning system was originally equipped with trombone shaped pipe coils through which the CO_2 passed and over which the return water from the air washers was literally "dumped." Copper finned coils over which the water is sprayed are now used, and this method has resulted in an increase in capacity. The use of copper tubing for the high working pressure necessary with CO_2 may be criticized as being poor practice, but after about nine years' service the installation is still in first-class condition. Heavy 1¼ in. OD finned copper tubing of No. 11 ga is used and, barring an occasional leak in one of the joints, has given highly satisfactory service, there being no tube failures to date. I might add that the tubing is guaranteed for 1500 lb working pressure and 3900 lb bursting pressure.

Water Conserving Equipment

A great deal was published during the early part of the year in the local press about the threatened water shortage in New York City, and the department of water supply, gas and electricity, taking advantage of the opportunity, has recently filed copies of certain rules and regulations with the city clerk pertaining to the use of "city water" for air conditioning, as reported on p. 294 of the May HEATING, PIPING AND AIR CONDITIONING. These regulations call for the installation of "a water conserving device such as economizer, evaporative condenser, water cooling tower or other similar apparatus, which device shall not consume for make-up purposes in excess of 15 per cent of the consumption that would normally be used without such device." In other words, New Yorkers *must* install cooling towers or some other form of water conserving equipment for the larger installations, and the make-up water is limited to 15 per cent. The regulations further state "such installations affected shall be equipped to conform with this rule by not later than April 1, 1942," or approximately two years hence.

Briefly, this means that to operate an air conditioning plant in New York City it will be necessary to conserve city water consumption by installing cooling towers presumably on the roof of the building in which the installation is made; this will apply to all but very small systems and provided there are not too many of these. The market for large evaporative condensers will be somewhat limited, as their use will be prohibited unless they are placed on the same floor level and somewhere near the refrigerating machinery, for it is illegal in New York City to run refrigerant lines vertically passing through other floors of the building. This will mean considerable expense to many high buildings, including hotels, as the vertical distance between the refrigerating plant in the

basement and the cooling tower on the roof will create a high static pressure on the equipment and piping in the basement and will therefore require extra heavy construction. At the New Yorker, for example, the static head is approximately 250 lb between the lowest basement and the roof and to install pumps and condensers as well as pipes and fittings to handle this pressure will increase the installation cost.

Put Refrigerating Plant on Roof?

If the use of cooling towers in New York City is to be a standard condition, as now appears certain, it may be cheaper both from an installation and operating standpoint to situate the entire refrigerating plant on the roof and pipe the cold water and/or brine to the lower floors where needed. Circulating brine at a low temperature to lower floors by means of a "loop" system of piping would make it possible to obtain the same refrigerating capacity with smaller pipes than with water and would permit the use of low pressure pumps as they would only be subjected to the pumping pressure. If air washers are desired by the designing engineer, circulating low temperature brine to a cooler near the air washer, or even cooling coils in the washer, could be used. While this is not a new idea, the present trend of events may force some buildings for economic reasons to adopt it.

Situating the refrigerating plant on the roof has many desirable features to commend it. To begin with, in New York City, many hotels have no power plant and purchase their electricity from the utility; there are others who also purchase their steam requirements. There is not much equipment left in the basement in a case of this kind except the refrigerating plant, the hot water heaters and house service pumps. Removing the refrigerating plant from the basement to the roof might help the architect in eliminating the need of digging a deeper foundation for an additional basement and with the elevator machinery and refrigerating plant on the roof less help might be needed to care for all this equipment.

Then again, many engineers might prefer to use ammonia as a refrigerant, but in New York City the code restrictions are so drastic that many designers do not even consider an ammonia plant in the basement. Personally, the writer feels that ammonia has no place in a hotel basement as a bad leak might cause a panic if a quantity of the gas were to get loose and spread through the lower floors; if used in a plant on the roof, however, I feel its otherwise good qualities would commend it.

In the end it might not cost any more to provide extra foundation and building steel to support the extra weight of the compressors, coolers, etc., than to excavate an additional basement possibly in solid rock. Placing the refrigerating equipment in a room on the roof with no inside connection to the rest of the hotel and adequate ventilating equipment in this space would remove any danger of ammonia fumes endangering or even annoying the guests.

[*A second article by Mr. Lewis will be devoted to hotel bedroom air conditioning.*]

More Air Conditioning for Gold Mines

By James A. Bentley*

Rivaling the adjoining Turf Shaft installation, a contract has been awarded for an air conditioning system extending operations in the Chris Shaft of the Robinson Deep gold mine at Johannesburg, South Africa, below the 8500 ft levels. The installation will include two centrifugal refrigeration machines with a cooling capacity equal to the melting of 4,000,000 lb of ice daily. The cooling system equipment, installed on the surface, is designed to supply approximately 400,000 cfm of cool air.

Wherever gold has been found, the mines are working night and day. The Rand district in the Union of South Africa is the greatest gold producing area in the world. Several of the mines there have reached the tremendous depth of 8500 ft below the shaft collar. At such depths, the heat and humidity are so extremely oppressive as to make it uneconomical to continue without air conditioning.

In 1935, what was then the world's largest air conditioning system was installed for the Turf Shaft, Robinson Deep, Ltd., of the New Consolidated Goldfields group, and this installation has proved of even greater value than was anticipated. Working conditions at the deeper levels have become satisfactory, resulting in greatly increased productive capacity, and benefiting the health of the miners. The present air conditioning system has reduced the former temperatures 27 deg near the surface and 9 deg at the bottom of the mine. This is accomplished by cooling the air to 33 deg at the surface and distributing it through the mine workings.

*Vice-president, Carrier Corp.

Summary of
More Air Conditioning for Gold Mines

By James A. Bentley

A contract has been awarded for an air conditioning system extending operations in the Chris Shaft of the Robinson Deep gold mine in South Africa below the 8500 ft levels; it includes two centrifugal refrigeration machines with a capacity equivalent to the melting of 4,000,000 lb of ice daily. The cooling system equipment, installed on the surface, is designed to supply approximately 400,000 cfm of cool air. . . . . The air conditioning system for the Turf Shaft, installed in 1935, has proved of even greater value than was anticipated in increasing productive capacity and benefiting health of the miners

PRACTICAL PIPING PROBLEMS

Thirty Years' Experience With a Steam Main

By W. H. Wilson*

MANY articles are written about the design and installation of piping systems, but it is seldom that anything is published on the service and maintenance problems that come up over a period of years. We have in our plant a steam main serving power plant units, steam hammers for forging work and process requirements for manufacturing that has been in practically continuous use, 24 hours a day, for over 30 years. I saw the pipe, valves and fittings for the job unloaded, helped install the main, and have spent some of my time for 30 years maintaining it. It is hoped that this "story of a steam line" may be of interest and some value to other piping men.

The boiler steam header section (*A*), and the part that runs overhead in the boiler house and in the tunnel to the center of the power house, is 20 in. diameter; at a double outlet tee at that point the size is reduced to 16 in. (*B*). The pipe is wrought steel, 3/8 in. thick, lap joints with flanges of semi-steel, bolt holes for 1 1/8 in. bolts. Flanged fittings, elbows and tees are of semi-steel. Flanged joints have smooth faces with 1/16 in. raised gasket contact face. The elbow shown at *C* is a special type placed in a horizontal position that causes the piping on the outlet end of the elbow to be 3 in. lower than the inlet, necessary because of the floor level in the power house. The 45 deg offset in the outside tunnel (*D*) is required because of existing buildings.

The boiler steam header rests on rollers supported by brackets with through bolts in the wall of the building. The overhead line across the end of the boiler house is held in place by split ring hangers with hanger rods from steel work in the roof of the building. In the outside tunnel, the line is supported by standard roller pipe supports resting on brick piers.

The pipe line in the power house is supported on piers and rollers, with the exception of the large double outlet tee with anchor base which is anchored securely to the concrete floor. Outlets are vertical. The continuation of the pipe line is reduced in size to 16 in. at

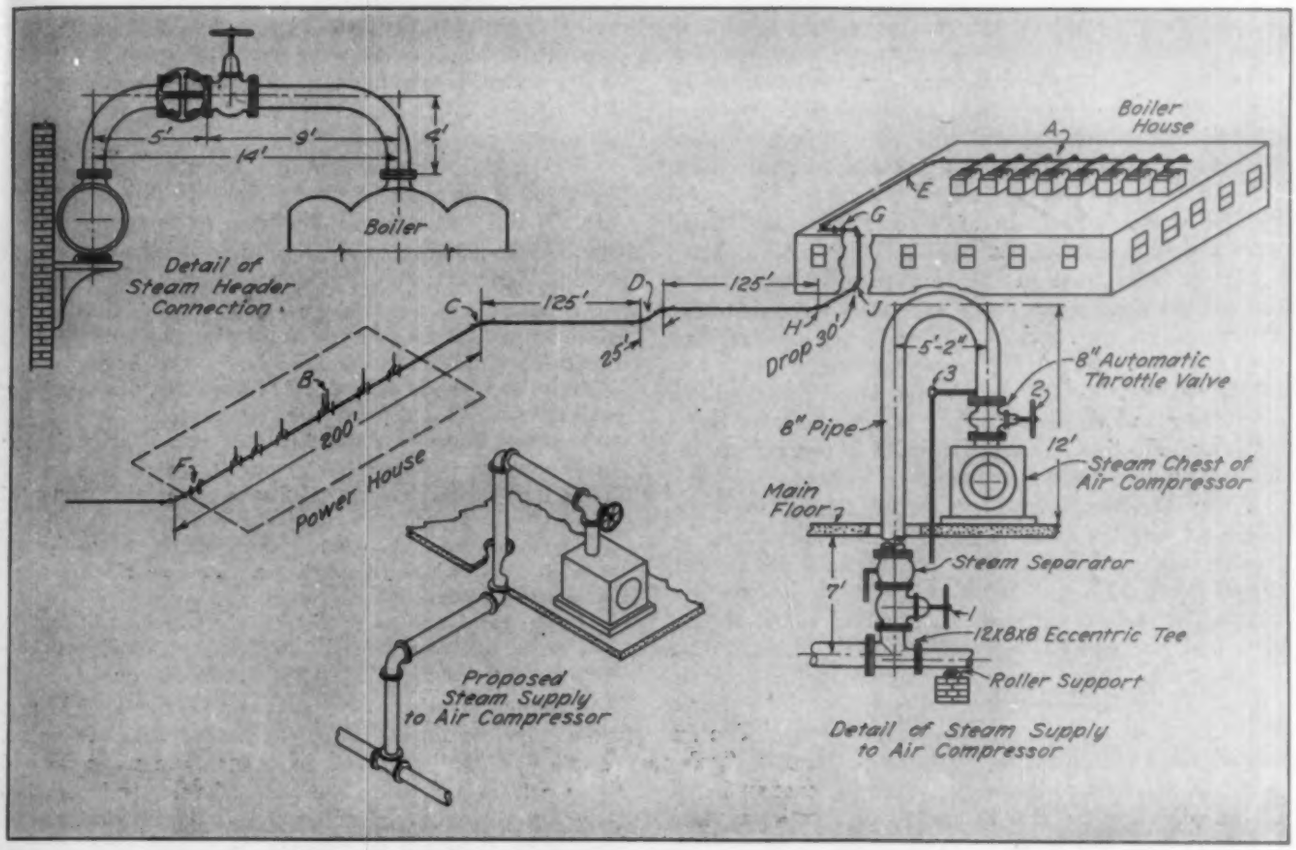
*Member of Board of Consulting and Contributing Editors.

Summary of

Thirty Years' Experience With a Steam Main

By W. H. Wilson

Mr. Wilson has lived with the 30 year old steam main he describes here; he saw the pipe, valves and fittings for the job unloaded, helped install the piping, and has spent some of his time since it has been in service maintaining it in condition for practically continuous use 24 hours a day. . . . . Many articles are written about design and installation of piping, but not often do we have the opportunity to review the operation and maintenance problems that come up over the life of a piping system. It is hoped that Mr. Wilson's story of the original installation, the changes that have been made, the problems that have come up and how they have been solved will be of interest and value to other piping men. . . . . In concluding, Mr. Wilson tells what they'd do differently today, if the main were to be replaced



this location, the end of the tee being eccentric. This fitting is the only fixed and anchored point in the power house. The steam line continues in the 16 in. size to near the end of the building and is then reduced to 12 in.; the reducing fittings are of the eccentric pattern. The line continues through the power house and outside of the building is reduced to 8 in. for the reduced pressure steam supply for forging hammers in a distant building. An automatic shut-off valve that closes on a sudden reduction of steam pressure on the delivery side is at *F*. At one time a fitting broke on the forging shop line and this valve closed instantly—satisfactory proof of the operation and usefulness of valves of this type.

No regular expansion joints are used in this pipe line from the boiler house to the end of the power house; no trouble was ever experienced with expansion and contraction in this piping.

The 20 in. main shut-off valve for the power house (*G*) is overhead in the boiler house. This valve is of the rising stem, outside screw and yoke pattern, semi-steel gate valve, installed with the stem in a vertical position. The gasket in the flanged bonnet has never been renewed. The valve stem packing is renewed about every four years, several different kinds of valve stem packing suitable for the pressure and conditions having been used with good results. The old packing when renewed was in fairly good condition and could have remained in service longer, but on account of the steam main being almost continually in service it seemed advisable to apply new packing. This valve has always operated easily. Once a year (when the steam main is out of service for the annual maintenance work) the valve stem threads are lubricated with graphite and the valve is opened and closed several times. This valve is not equipped with a bypass. No trouble was ever experienced in turning on steam in this pipe line.

During the first few years that this main was in service, considerable vibration occurred. The main was then anchored in the center, back of the boilers. Later it was anchored near the main shut-off valve, overhead in the corner of the boiler house and also at the elbow *H* in the corner of the tunnel.

The photograph shows the location of the boiler steam header valves. The valve to the right hand (nearest the boiler) was removed a few years after the installation of the boilers and a different type of automatic boiler stop and check valve installed, with the valve stem in a vertical position, as per the detail of the steam header connection. This is a decided convenience in getting to the bolts and nuts on the valve bonnet for inspection and repairs (in addition to being the proper way to install a valve of this type). The valve to the left hand (nearest the steam header) is a gate valve of the solid wedge gate and outside screw and yoke pattern.

The pipe line is insulated with 1½ in. magnesia pipe covering. At the present time the covering is in fair condition. When the piping was first installed, 125 lb steam pressure was maintained. After a few years in service the steam pressure was increased to 180 lb. Later, for a period of a few months, pressure was increased to 195 lb and then brought back to 180 lb, which is the pressure at present. Two of the boilers are equipped with superheaters. A recent check of the steam temperature showed 438 F in the boiler steam header and 428 F in the steam main at the center of the power house. Some needed maintenance work on the pipe insulation would no doubt lessen the temperature drop.

The first gaskets used in the pipe line joints were of

the self sealing type—a narrow copper ring filled with sheet packing. Four of these original gaskets are still in service. Gasket renewals were principally caused by the vibration in the pipe line, as mentioned. Some of the gaskets used for renewals are of the corrugated metal type, ring pattern, with a gasket of asbestos sheet packing 1/32 in. thick placed on each side of the corrugated metallic gasket. Faces of all three gaskets are coated with a suitable gasket cement.

Flange bolts used in the original installation were commercial steel, square head bolts with hexagonal nuts. When gaskets are renewed, bolt studs and nuts of alloy steel are used. By having hexagonal nuts on each side of the flanges in the joint, the labor required for assembling and tightening flange bolts is simpler, better and more effective. Gaskets renewed in the manner described have not shown any signs of leakage.

When the pressure and temperature of the steam was increased, the line was checked for expansion but no trouble was experienced. The points anchored, as mentioned previously, were anchored when the steam was on the line and the increase was opposite to the anchorages and not enough to cause trouble. The increase in travel was noticed mostly at the riser for the air compressor at the far end of the power house, 80 ft distant from the fixed point at the anchorage fitting. The expansion was taken care of by the pipe bend or "goose neck" in the riser at that point. The increase in length of the pipe line for the 80 lineal feet mentioned, total temperature of 454 F, was approximately ½ in.

At one time when the main was down for repairs, one of the jobs was to renew a gasket between two tees on the boiler header. Apparently the gasket contact faces were not carefully scraped and cleaned of all the parts of the old gasket. At the close of the working day allotted for these repairs, steam pressure was turned on and the joint was leaking. No time being available for shutting down and opening up the joint for putting in a new gasket, additional tightening was done on the flange bolts to such an extent that the outside edges of the flanges on the fittings were drawn in so as to be perceptible to the eye. Although strained, the semi-steel flanges did not crack. This joint leaked badly for several days until arrangements were made to inject a plastic compound with a pressure gun in the joint, which stopped the leak. A year later when the steam main was shut off for regular maintenance and repairs, this joint was opened and as was expected failure in scraping the gasket contact faces of the fittings clean was what caused the leakage. A new gasket was installed at this time and is still in service.

Attention is called to the eccentric pattern tees reducing on the run in the power house, which allow the water of condensation to follow the steam flow and leave the interior of the main at the drips and enter the steam traps. Also the drains from the steam separators on the vertical risers are connected to the trap line. When this main was first installed all of the drips and drains from the power units were connected to a single steam trap. This included the drips from the separators on the vertical risers of the steam supply to the air compressors. At one time when all of the air compressors were in operation the air compressor at the end of the building was shut down and at this time the bonnet of the drain valve on a steam separator blew off. The cause of this was attributed to a backward surge of steam and water of condensation through the common drip line to the steam trap. After this, individual steam traps were installed for each unit to be drained.

The piping, valves and fittings are apparently in safe condition at the present time. The pipe line is in daily use. If this steam supply line were to be renewed or a similar one installed today, the following changes would be considered:

All pipe fittings and valves would be of steel, although the present semi-steel fittings have served their purpose.

Welding fittings and welded pipe joints would be used.

A base elbow would be used at *J* to support the vertical piping, with the elbow free to move on its base.

The elbow in tunnel *H* would be provided with an anchorage base on its side to securely anchor at this point.

The pipe line overhead in the boiler house would be supported on wall brackets similar to the boiler header.

Piers in the tunnel and power house would be concrete instead of brick. Bricks have become loosened in some of these piers, necessitating replacement and repair.

Special attention would be given to the selection and application of the pipe covering and insulation, double layer covering with joints broken and well applied being used.

Attention is called to the vertical riser and bend "goose neck" pipe connection to the engines, as shown in detail. While this method is neat in appearance when viewed from the main floor of the power house, and compensates for the linear expansion travel in the pipe line, it has been a source of trouble from the time it was installed. When the engine throttle valve is closed, water of condensation accumulates in the part of the bend above the throttle valve. The temperature change causes the gasket joints to leak. A small steam trap has been placed at *3* to relieve this condensation. The following would be considered for any future installation:

Relocate the steam main in the basement to one side of the center line of the throttle valve and install piping connections as shown in detail. Use a throttle valve of the angle pattern type. This would avoid having an accumulation of condensation when the throttle valve is closed, compensate for expansion and contraction and to the practical operating man it would be suitable when viewed from the standpoint of appearance.

Panel Heating Construction

The forced circulation hot water heating system for the Air Ministry Headquarters in London, England, was illustrated and briefly described on p. 170 of the March, 1940, HEATING, PIPING AND AIR CONDITIONING. It was mentioned that panel type radiators are used in the offices, and that there are floor heating panels in the main entrance hall.

The panel type radiator consists of a plate for setting either flush in the wall or on the face of the wall. This plate may be heated by either hot water or steam carried through waterways on the back of the panel. The plate extends at the top and bottom and each side beyond the waterways, and the piping connections to the waterways can therefore be concealed behind the panel.

The flooring panels (shown in the sketch) are constructed of steel and consist essentially of three parts—the front plate, the waterway tubes, and the carrier and diffuser plate.

[*Concluded on p.* 355]

Types of Drawings Used in Power Piping Drafting

By Albert Jorgensen*

FUNCTIONS of the power piping draftsman and the problems with which he is confronted were discussed in a general way in the April HEATING, PIPING AND AIR CONDITIONING. The drawings which usually are supplied to facilitate the fabrication and erection of a power piping system were mentioned; these are the plot plan, general building plans, piping diagrams, piping assembly drawings, details of pipe supports, and shop drawings.

The purposes and characteristics of the first three of these were considered in April, and in May we took up piping assembly drawings and pipe support details. This discussion of power piping drafting is completed this month with consideration of shop and other drawings, specifications and models.

Shop Drawings

In the majority of cases the piping contractor is required to submit for approval shop drawings which ordinarily are made by the fabricating company. These show in detail how the piping system is to be fabricated; the usual requirement is that the piping be prefabricated in the shop as much as possible. Due consideration must be given shipping and erection limitations, of course. The smaller lines may be fitted on the job. Fabrication layout sketches of the more important lines are provided which show, in addition to other things, the locations of field connections and cold springing details. Cold springing is accomplished by making the pipe between anchorages too short for natural closure at the installation temperature and then pulling the ends together while the connection, whether it be welded or bolted, is made. The purpose of cold springing is to compensate partially for expansion stresses. Fig. 1 shows a fabrication layout sketch together with the corresponding design drawing. The material shown in this figure was designed to serve as a guide to fabricators doing work under the direction of the engineering firm that supplied the drawing.

In order to systematize estimating, fabrication, shipping and erection it is well to introduce a marking system in making shop drawings of piping. Each separate piece of the piping system between field connections is given an identification mark which is shown on the drawings and also is painted on the piece in the shop. These separate pieces may be valves, fittings, lengths of pipe, expansion joints, pipe bends, etc. The mark carried by a piece usually consists of a letter or letters and a number. The letters identify the line (such as "MS" for main steam line and "BF" for boiler feedwater line) and the numbers identify the piece in the line. The pieces are usually numbered consecutively from one end of the line to the other. For instance, a valve might carry the designation "MK-MS-10." "MK" is an abbreviation of the word "mark," the letters "MS" indicate that the valve is in the main steam line, and the number "10" shows that the valve is item No. 10 in the line. The pieces adjacent to the valve, if there are two, would be given the marks "MK-MS-9" and "MK-MS-11." In many instances the valves are not numbered or are given a separate series of numbers.

In addition to the shop drawings of the type just mentioned, a separate shop drawing of each piece which requires any considerable amount of individual shop work, is drawn. These are designated as "sketches" in the trade, although drawing instruments are used in making them. Figs. 2, 3, 4 and 5 are examples of such sketches.

An explanation of some of the notes may make these sketches more intelligible to the reader. On Fig. 3 the note "6x12½x1⅝-400# FS. SO. FLG. F & D. 12-1" H-10⅝ BC. WELD BK. & FRT." applies to the flanges indicated and states that they are to be 6 in. nominal pipe size, 12½ in. in diameter, and 1⅝ in. thick, suitable for 400 lb per sq in pressure, forged steel, slip-on flange, faced and drilled, twelve 1 in. stud bolts with hexagonal nuts on a 10⅝ in. diameter bolt circle, weld back and front. On the same figure "GR. A-SMLS." means "grade A seamless pipe." On Fig. 5, "WN." in the flange notes means "welding neck."

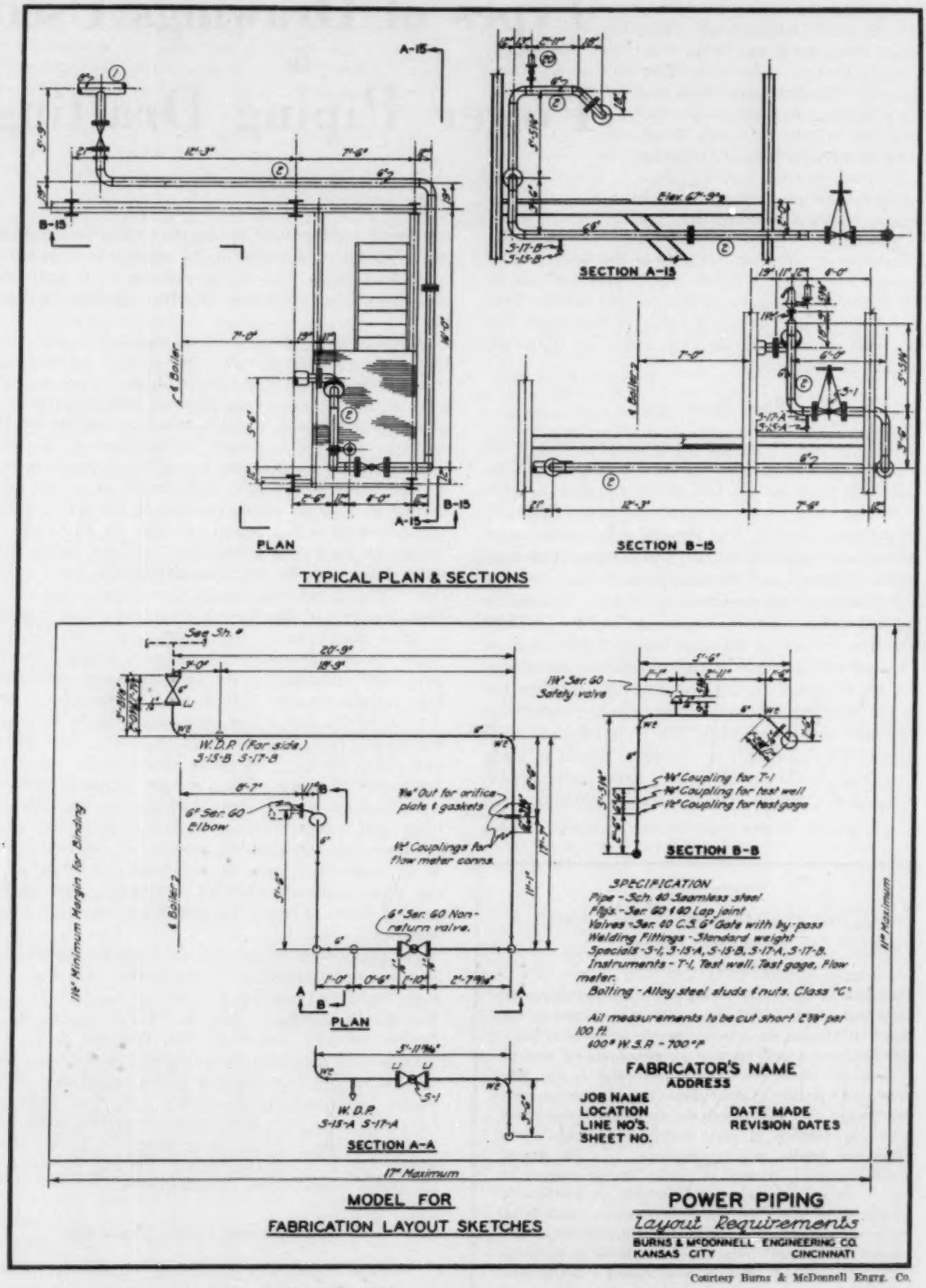
Other Power Piping Drawings

Additional drawings which may be included in a set of power piping plans are welding details, details of instrument connections, details of connections to sampling devices, and a table of machinery outlets, which shows

*Assistant Professor, General Engrg. Drawing, University of Illinois.

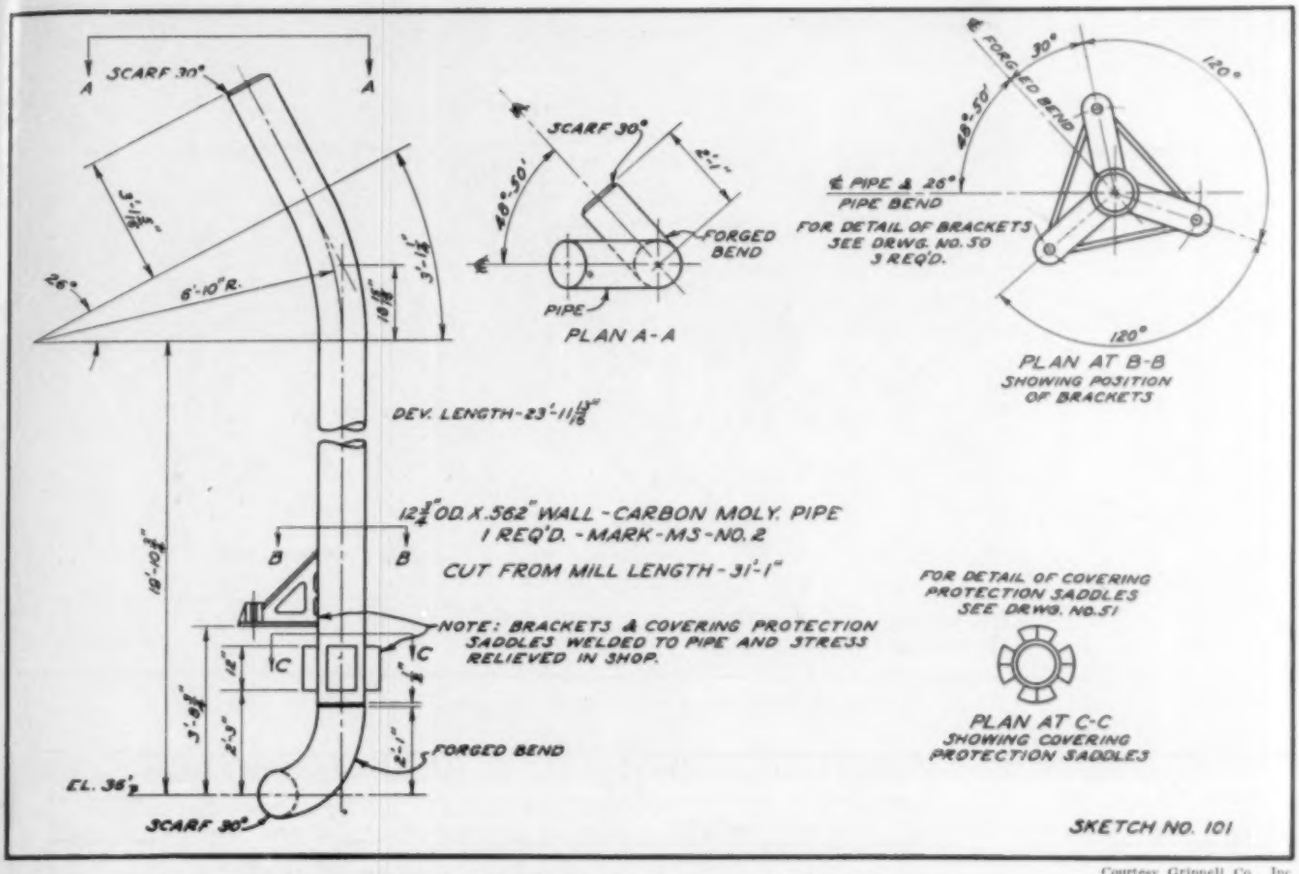
Summary of
Types of Drawings Used in
Power Piping Drafting
By Albert Jorgensen

Functions of the power piping draftsman and the problems with which he is confronted were outlined in the April HPAC, and the drawings usually supplied to facilitate fabrication and erection of power piping systems were given; these were further discussed in the May issue, and examples of the various types of drawings were reproduced. . . . This month the discussion is concluded with consideration of shop drawings, "sketches," miscellaneous details, and specifications. . . . The use of piping models is referred to briefly, and an example of one is shown. Complete scale models of portions of power plants where the piping is congested result in an improved appearance of the final design and lead to convenient arrangement from the standpoint of plant operation, it is claimed. Models also present a much more intelligible representation than do drawings for executives and others who are concerned with the plant design



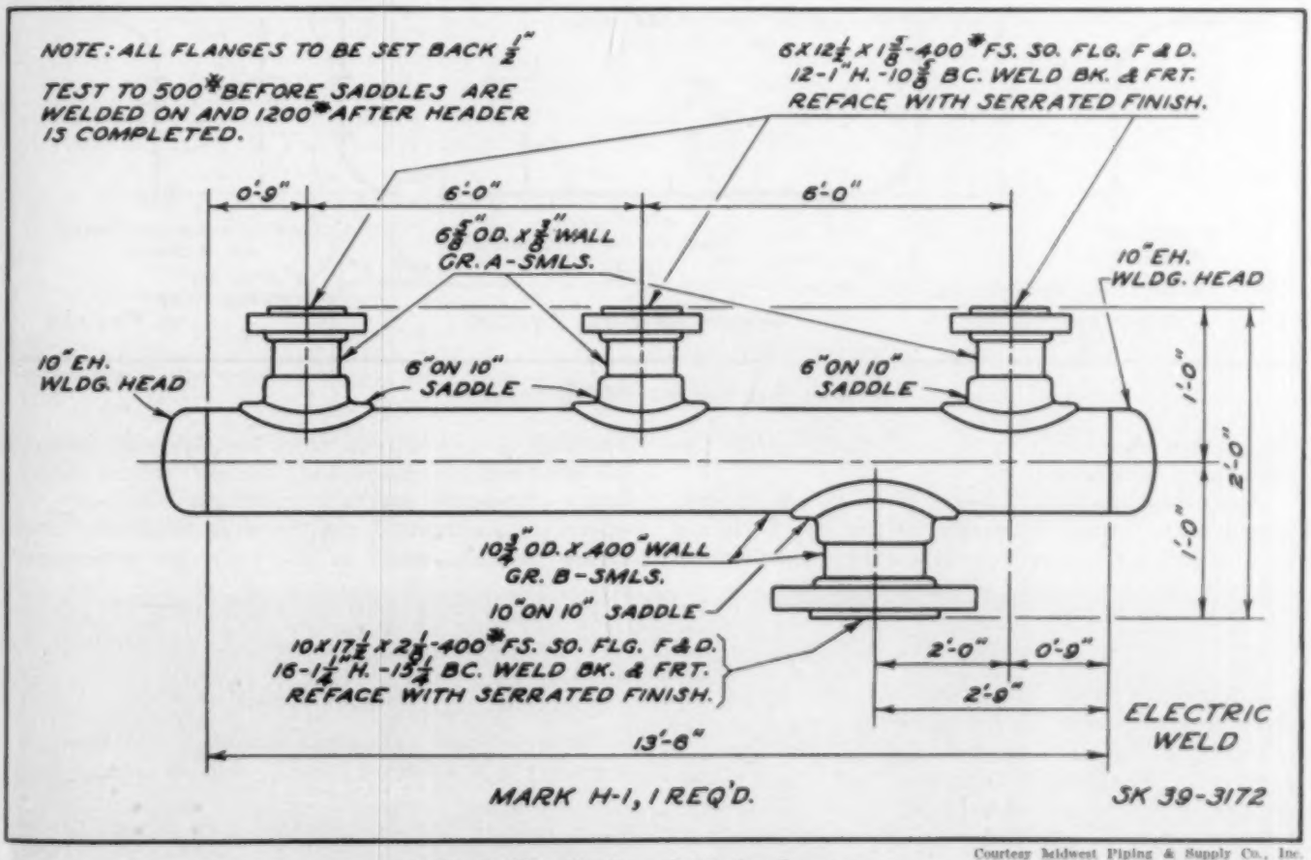
Courtesy Burns & McDonnell Engrg. Co.

Fig. 1—Fabrication layout sketch with corresponding design drawing



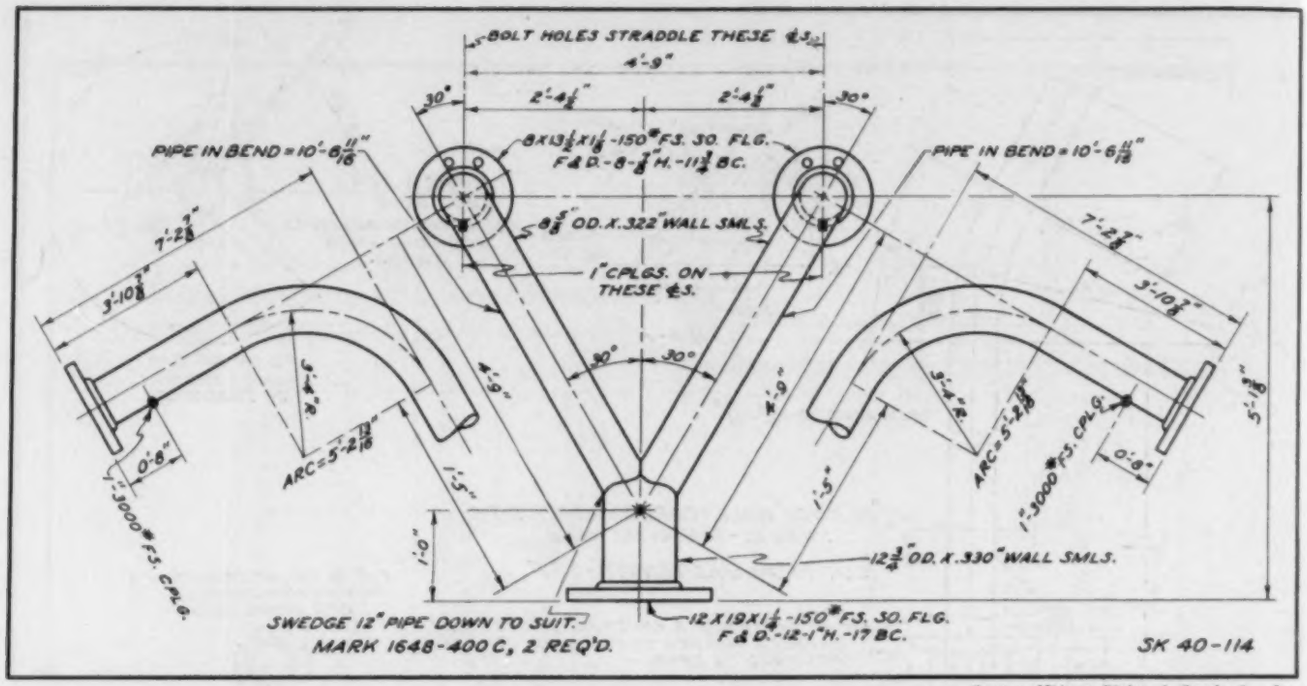
Courtesy Grinnell Co., Inc.

Fig. 2—Shop drawing. Original scale, $\frac{3}{8}$" = 1' 0"


NOTE: ALL FLANGES TO BE SET BACK 1/2"
TEST TO 500# BEFORE SADDLES ARE WELDED ON AND 1200# AFTER HEADER IS COMPLETED.
6 X 12 1/4 X 1 5/8 - 400# FS. 30. FLG. F & D.
12-1" H. - 10 5/8 BC. WELD BK. & FRT.
REFACE WITH SERRATED FINISH.
0'-9"
6'-0"
6'-0"
6 5/8" OD. X 3/4" WALL
GR. A - SMLS.
10" EH. WLDG. HEAD
10" EH. WLDG. HEAD
6" ON 10" SADDLE
6" ON 10" SADDLE
1'-0"
2'-0"
1'-0"
10 3/4" OD. X .400" WALL
GR. B - SMLS.
10" ON 10" SADDLE
10 X 17 1/2 X 2 1/8 - 400# FS. 30. FLG. F & D.
16-1 1/4" H. - 15 1/4 BC. WELD BK. & FRT.
REFACE WITH SERRATED FINISH.
2'-0"
0'-9"
2'-9"
ELECTRIC WELD
13'-8"
MARK H-1, 1 REQ'D.
SK 39-3172

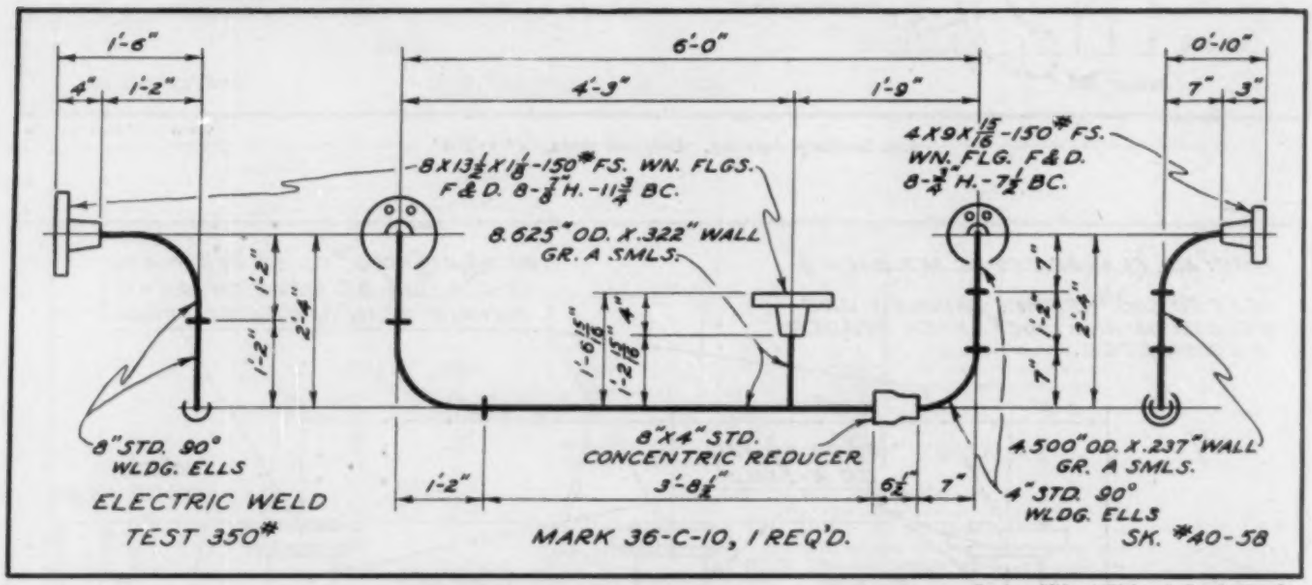
Courtesy Midwest Piping & Supply Co., Inc.

Fig. 3—Shop drawing. Original scale, none



Courtesy Midwest Piping & Supply Co., Inc.

Fig. 4—Shop drawing. Original scale, none



Courtesy Midwest Piping & Supply Co., Inc.

Fig. 5—Shop drawing. Original scale, none

the terminal connections on the equipment to which the piping is to be attached.

Piping drawings used in power plants as aids in plant operation are worthy of mention. These may be in the form of pictorial piping diagrams, either isometrics or obliques, and they carry operating instructions in the form of notes.

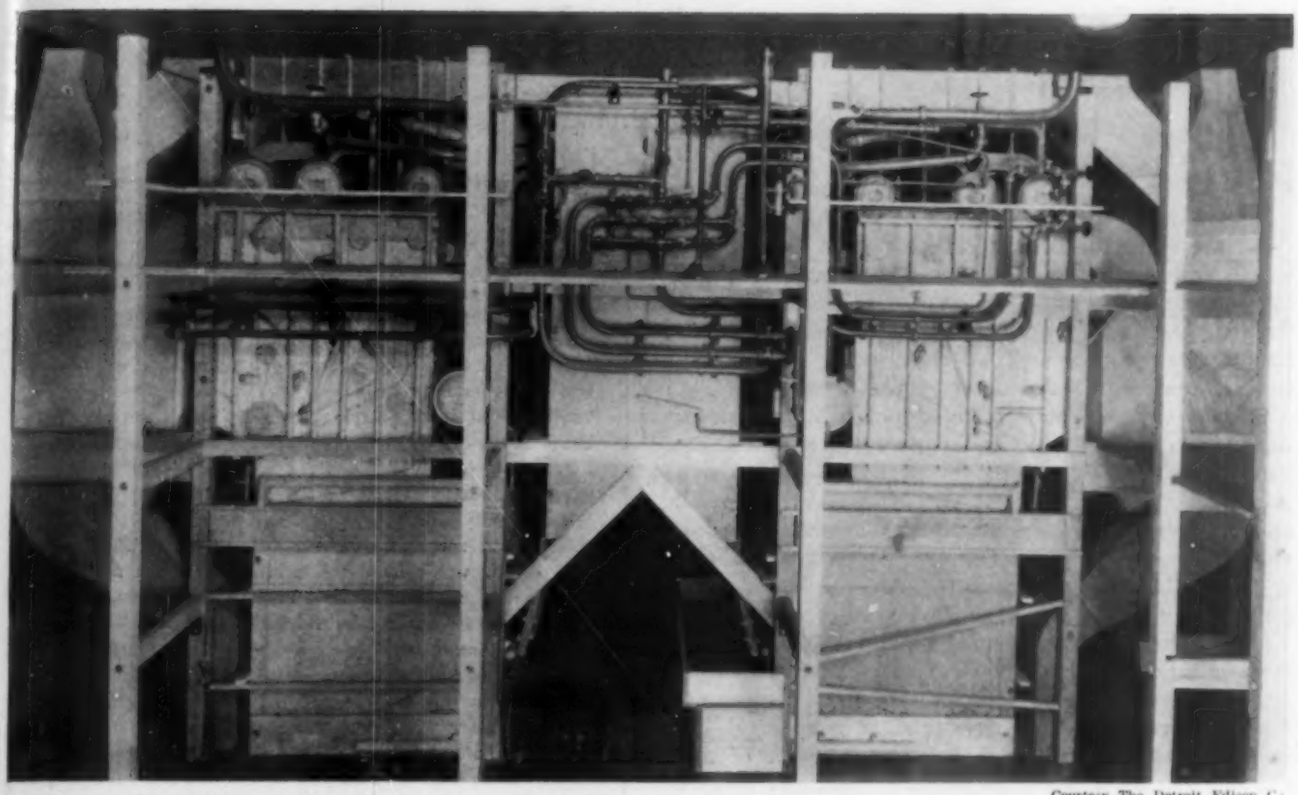
Specifications

Since it is undesirable to cover the drawings to too great an extent with notes, specifications which supplement the information given on the drawings are prepared. These, besides defining the rights and responsibilities of the owner and the contractor, specify the performance to be expected of the equipment to be furnished, the qualities of the materials to be used, and the standards of workmanship which are to prevail. Numerous references are made to the Code for Pressure Piping, which covers the general requirements necessary for safety, the standards of the American Standards Association (ASA), which in the main are dimensional standards, and the specifications of the American Society for Testing Materials (ASTM), which for the most part cover the chemical and physical properties of the materials.

Use of Models

Because of their satisfactory experience with them, the engineers of The Detroit Edison Co. advocate[1] that com-

[1]See Models Make for Accessibility in Delray Piping, by Frank Sharp and R. M. Van Duzer, Jr., *Power*, Vol. 70, p. 956, December 17, 1929; also Chapt. 7, Modernizing the Conners Creek Power Plant, by Sabin Crocker, *Combustion*, Vol. 7, No. 12, p. 27, June, 1936; and pp. 746-748, Piping Handbook, by Walker and Crocker, 3rd ed., 1939.



Courtesy The Detroit Edison Co.

Fig. 6—Complete scale models of portions of a power plant where the piping is congested result in a better appearing and more convenient final design and present a more intelligible representation than do drawings to those executives and others unfamiliar with the details. This is a model of boilers and piping

plete scale models be built of those portions of a power plant in which the piping is congested. Fig. 6 shows such a model. The procedure is to make a preliminary design and then build models, improving the layout as faults become obvious. The final drawings are based on the finished models, in which are incorporated all those features which represent the best design. The advantages claimed for this practice are improved appearance and a more convenient arrangement from the standpoint of plant operation. To executives and others who are concerned with the design of a plant but are unfamiliar with the details, models present a much more intelligible representation than drawings.

These articles on piping drafting were based on a number of sets of design drawings and specifications furnished by engineering organizations, and on shop drawings supplied by fabricating companies.

The author wishes to express his gratitude to the organizations that supplied the drawings and also to the engineers whose aid and constructive criticisms made possible these articles.

[This is the third of three articles on power piping drafting]

Panel Heating Construction —

[Concluded from p. 350]

The front plate of these panels is formed of an expanded metal grid which acts as a reinforcement and at the same time a keying grid upon which the marble is fixed. The marble itself forms the actual heating surface at a temperature of about 100 F.

The waterway tubes are built from "D" section tubes, 1⅝ x ¾ in., welded each end into "D" section headers. Screwed connections are welded into these headers in any position for flow and return headers. Waterway tubes are brought into metallic contact with the front plate by means of the carrier and diffuser plate. This plate is made of soft steel, and accurately conforms to the shape of the "D" tubes. This particular form of construction leaves the waterway tube free to move irrespective of the front plate.

Panel heating element for use in floor and walls

Ventilation of Air Raid Shelters

By Thomas C. Angus*

Summary of
Ventilation of Air Raid Shelters
By Thomas C. Angus

Apprehension of bombing from the air has intensified the need for mechanical ventilation of buildings in England, which have usually depended upon sash windows and skylights for ventilation, for the necessity of preventing light from escaping from buildings during the hours of darkness often makes open windows impossible. . . . Design of air raid shelters that will protect against explosive bombs falling anywhere but directly on top is now pretty well established, and ventilation for such shelters has received considerable attention. The total area of the walls, floor and ceiling of such a room is taken as the criterion of the number of occupants, rather than the cubic content, the disposal of personal heat and moisture being deemed more important than the diminution of oxygen or accumulation of carbon dioxide. . . . Investigations of the atmospheric conditions in such shelters have been made, and some of the results are indicated in the graph. . . . A number of ventilation appliances for air raid shelters are on the market, consisting generally of a fan drawing air through beds of activated charcoal. Fans are electrically driven but in event of current failure a hand or bicycle type drive is provided

THE war and the apprehension of bombing from the air, with or without poison gas, has intensified the need for mechanical ventilation in business houses and factories in England. Such buildings have usually depended upon hot water radiators for their warming and upon sash windows and opening skylights for their ventilation—both of these being locally controlled according to the tastes of the occupants. The wartime necessity to prevent any appreciable light escaping from a building during the hours of darkness has made open window ventilation impossible and causes great discomfort in the late afternoon and evening in crowded offices where no mechanical ventilation is provided. Where night shifts are employed the condition is even more serious. The introduction of "light traps" for shades and doors may improve matters.

In certain localities it is legally compulsory for the proprietors of buildings in which persons are employed to provide adequate retreats for their workers for use during air raids. As such retreats are generally below grade and are likely to be crowded the question of ventilation may be of great importance, especially in view of the possibility that gas bombs or sprays of poisonous liquids may be discharged from airplanes.

The design of air raid shelters that will protect against explosive bombs falling anywhere but directly on top of them is now pretty well established and a great many such shelters have been constructed. The provision of ventilation has received much attention and there has been some question as to whether or not it is necessary to provide mechanical ventilation for such shelters.

*Department of Industrial Physiology, London School of Hygiene and Tropical Medicine.

Fan unit for electric drive or hand operation

At the time of the September, 1938, crisis, instructions were issued for making gasproof a room in any dwelling house. This room is to have protected windows and is to be sealed up as hermetically as possible. All doors are to be closed in the event of a gas attack. The total area of walls, floor and ceiling of this room is to be taken as a criterion of the number of persons it may hold, rather than its cubic content, it being considered that the disposal of personal heat and moisture is of prior importance rather than the diminution of oxygen or accumulation of CO_2. It is also considered that the materials of ordinary buildings act, to a certain extent, as filters against poison gases.

A valuable investigation of a most practical character has been carried out at the works of Messrs. J. and E. Hall, Ltd., of Dartford, Kent (Refrigeration Engineers), to whom I am indebted for permission to reproduce some of these data. The technical staff of this firm, with doctors, and investigators from the Department of Industrial Physiology of the London School of Hygiene and Tropical Medicine, carried out the tests and reported the results. Their report describes the results found during prolonged occupancy of two typical types of air raid shelter, when completely sealed, and both with and without the employment of various means to maintain breath-

[*Concluded on p.* 361]

Radiant Heating and Cooling

What It Is and How It Is Figured

By F. E. Giesecke*

HEAT may be conveyed by conduction, by convection or by radiation. In the present state of the art of heating and cooling buildings, the transfer of heat is most commonly effected by convection, to a lesser extent by radiation, and least by conduction. However, in every heating or cooling installation, all three methods of heat transfer are present.

If a room is heated by means of a free-standing radiator filled with steam or hot water the heat transfer from the radiator to the room is about 30 per cent by radiation and about 70 per cent by convection. If a room is heated by means of warm air, the heating is effected almost exclusively by convection. However, in this case, the ceiling and one or more of the walls are warmer than other parts of the room and its contents and they dissipate their excess heat by radiation. The only case in which heat is transmitted purely by radiation is that in which the radiant energy passes through a vacuum. For example, the flow of heat from the sun to the earth is purely by radiation.

Before discussing radiant heating and cooling in detail, it is important to develop a clear understanding of the nature of *heat* and of *radiant heat*, so-called.

Heat Is Kinetic Energy of Molecules

If two iron bars (Fig. 1) are exactly alike except that one is warmer than the other, the difference between them is that the molecules in the warmer bar move with a higher mean velocity than those of the cooler bar.

It is difficult to realize that an iron bar is not a single rigid body but that it is an aggregation of an exceedingly large number of exceedingly small molecules which are so close together that they cohere with great tenacity and yet are far enough apart so that they are in continuous motion so long as the iron bar has a temperature above —460, the absolute zero of the Fahrenheit temperature scale.

In the case of liquids and gases, it is easier for us to realize that they are aggregates of molecules because one is familiar with the phenomenon of evaporating water, i.e., of transforming water into steam simply by increasing the distances between molecules. If 1 cu ft of water is evaporated at ordinary temperatures and pressures, about 1600 cu ft of steam is formed. If one assumes that the molecules in the steam are of the same size as those in the water and that the molecules in water are practically in contact with each other, it follows that the distance between centers of molecules in the steam must be about 12 molecule-diameters (Fig. 2) because the cube root of 1600 is about 12. At like temperatures and pressures, all gases have the same number of molecules in a given volume. The molecules in ordinary saturated air may, therefore, be represented as shown in Fig. 2.

The size of the oxygen molecule is about 1 in. divided by 125,000,000. Its mean velocity is about 1500 feet per second. Since all molecules in a given gas have the same kinetic energy, the mean velocities of the nitrogen and the water molecule are about 1600 and 2000 fps, respectively, when that of the oxygen molecule is about 1500, because their masses are correspondingly smaller than that of oxygen.

In the preceding discussions, molecules were referred to as if they were spherical bodies. This is not the case. A molecule is composed of atoms which move

Summary of
Radiant Heating and Cooling

By F. E. Giesecke

Before discussing radiant heating and cooling in detail, it is important to develop a clear understanding of the nature of heat and of so-called radiant heat. Heat is the kinetic energy of molecules, the difference between, say, a warm iron bar and a cold iron bar being only that the molecules in the warm bar are moving with a higher mean velocity than are those in the cooler bar. One result of the complicated molecular, atomic and electronic motions in a body is that energy is continuously radiated from the surfaces of all bodies whose temperatures are higher than absolute zero (—460 F). Radiant energy having a wave length from about 4000 to 400,000 angstroms (an angstrom being one meter divided by 10,000,000,000) is known as radiant heat because when it impinges on a body it increases the kinetic energy of the molecules of the body and therefore its heat content and temperature. Radiant heat is that radiant energy which is partially transformed into heat when it is intercepted by a body. . . . . The rate at which a perfect radiator (black body) radiates energy is $Q = 0.174 (T/100)^4$, where Q is Btu per sq ft per hr and T is absolute temperature, or degrees Fahrenheit plus 460. It is sufficiently accurate to use a constant of 0.156 for materials used in building construction, in place of 0.174 as given in the preceding equation. Heat transferred by radiation from a warmer to a cooler surface thus may be calculated by the equation $Q = 0.156 [(T_1/100)^4 - (T_2/100)^4]$. . . . .If the temperatures of the surfaces in a room are not equal to each other, but differ only slightly, the mean radiant temperature may be calculated by multiplying the area of each surface by its temperature and dividing the sum of the resulting products by the sum of the surface areas—the quotient is the *mean radiant temperature*. . . . . When a room is heated by means of a warm ceiling, air convection currents are produced which transmit additional heat from the ceiling. To calculate this quantity of heat it is necessary to know the film coefficient for transfer of heat from the ceiling to the air; for a ceiling it is probably less than the Guide figure of 1.65 for interior walls—possibly 1.0. Accurate calculations of this part of the problem can only be made after reliable data are available from carefully conducted research; at present, it seems to be sufficiently accurate to assume the heat transmitted from the ceiling by convection to be about 50 per cent of that by radiation

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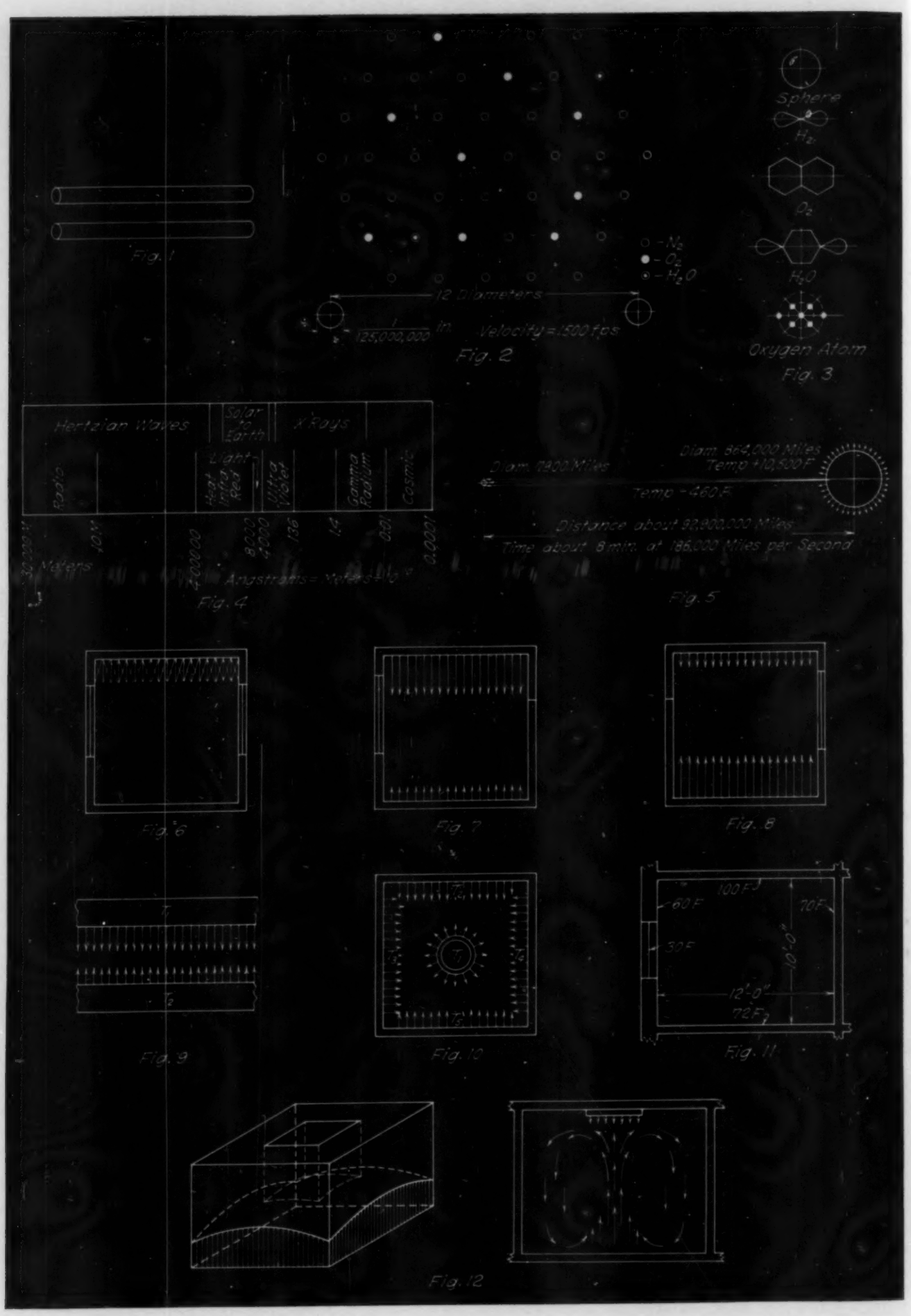


Fig. 1
12 Diameters
1/125,000,000 in
Velocity = 1500 fps
Fig. 2
N_2
O_2
H_2O
Sphere
H_2
O_2
H_2O
Oxygen Atom
Fig. 3
Hertzian Waves
Radio
Solar to Earth
Light
Heat Infra Red
X Rays
Ultra Violet
Gamma Radium
Cosmic
30,000 M
10 M
2,000,000
8,000
4,000
136
1.4
0.01
0.0001
Angstroms = Meters 10^{-10}
Fig. 4
Diam. 1900 Miles
Temp. −460 F
Diam. 864,000 Miles
Temp. +10,500 F
Distance about 92,900,000 Miles
Time about 8 min. at 186,000 Miles per Second
Fig. 5
Fig. 6
Fig. 7
Fig. 8
Fig. 9
Fig. 10
60 F
100 F
70 F
30 F
12'-0"
72 F
Fig. 11
Fig. 12

about within the molecule. The atom has a very complicated structure, as indicated in Fig. 3; it consists of a central body surrounded by electrons which move about within the atom.

One result of these complicated motions (or some of them)—molecular, atomic, and electronic—is that energy is continuously radiated from the surfaces of all bodies whose temperatures are higher than — 460 F. The nature of this radiant energy is not definitely understood. It is believed that the energy is radiated in pulsating discharges of small units called *quanta* or *corpuscles*. The effect of the pulsating discharges is the same as that of wave motion; the corresponding waves are electro-magnetic waves. It is known that the energy is radiated from every point of every surface, in all directions, in straight lines, and at a very high velocity—about 186,000 miles per second. It is also known that the intensity of the radiant energy varies with the character of the surface from which it is radiated, that it is proportional to the fourth power of the absolute temperature of that surface, that its intensity varies inversely as the square of the distance from the source, and that it is propagated in waves of widely varying lengths (Fig. 4). The longer waves are measured in meters; the shorter waves in *angstroms*. An angstrom is one meter divided by 10^{10} or by 10,000,000,000.

Radiant energy of the longer wave lengths is used for radio transmission and that of shorter wave lengths for x-ray work. Radiant energy having a wave length of from 8000 to 4000 angstroms is that peculiar type which can be sensed by the human eye—light—and which gives the human mind the sensation of color—red, yellow, blue, and their innumerable gradations. Radiant energy having a wave length of from about 4000 to about 400,000 angstroms, with the maximum effect at about 20,000, is known as *radiant heat*, because when this radiation impinges on a body it accelerates the molecular motion in that body, i.e., it increases the kinetic energy of the molecules and therefore the heat content and temperature of the body. In other words, *radiant heat is that type of radiant energy which is partially transformed into heat when it is intercepted by a body.*

Fig. 1—Two iron bars exactly alike except that one is warmer than the other. The only difference between them is that the molecules in the warmer bar move with a higher mean velocity than those of the cooler bar. . . . Fig. 2—The molecules in saturated air. . . . Fig. 3—Diagrammatic representation of the atoms in hydrogen, oxygen, and water molecules and of the structure of an oxygen atom. . . . Fig. 4—The varying wave lengths of radiated energy. . . . Fig. 5—The sun, the most important radiator for mankind. . . . Fig. 6—Energy radiated in all directions from every point in the ceiling (also from every point in the floor and walls). . . . Fig. 7—The ceiling functioning as the heating element or radiator for the room. . . . Fig. 8—The ceiling functioning as the cooling element or refrigerator for the room. . . . Fig. 9—The transfer of radiated energy between two large and parallel surfaces, near each other, and at different temperatures. . . . Fig. 10—The transfer of radiated energy when one radiating surface is entirely surrounded or enclosed by the other. . . . Fig. 11—A room 12 ft by 15 ft by 10 ft high. Ceiling temperature is 100 F. Mean radiant temperature of remaining five surfaces (floor and four walls) is 67.6 F. . . . Fig. 12—Temperature distribution over the floor of a room heated by a panel in the ceiling and the air currents which are produced thereby

Amount of Heat Radiated

When radiant energy impinges on a body a part of the energy is reflected, a part is absorbed, and a part passes through the body. The rate at which a body absorbs the radiation which impinges on it is proportional to the rate at which that body radiates energy. If a body absorbs all radiant energy which impinges on it, it is a *perfect absorber*. Such a body is also a *perfect radiator*. There is no perfect radiator in nature. A body with a rough surface coated with lamp black is almost a perfect radiator and, for that reason, a perfect radiator is called a *black body* and its radiation is called *black radiation*. All other radiation is called *gray radiation*. The rate at which a perfect radiator (black body) radiates energy is

$$Q = 0.174 \times \left(\frac{T}{100}\right)^4 \qquad [1]$$

where Q = Btu per sq ft per hr and T = absolute temperature = degrees Fahrenheit plus 460.

If such a body has a temperature of 100 F (560 T) it will radiate energy at the rate of 0.174 $(5.60)^4$ or 171 Btu per sq ft per hr. The radiation factors of some of the materials commonly used in building construction, which should be employed in place of the constant 0.174 in Equation 1, are:

Brick	0.162	Glass	0.156	Paper	0.162
Cast iron	0.150	Linoleum	0.154	Stone	0.147
Cloth	0.136	Mortar	0.158	Wood	0.158

Since the data for heating and cooling calculations are generally quite variable, it is not necessary to use extreme refinement in such calculations and it is sufficiently accurate to use a common radiation factor of 0.156 for stone, brick, mortar, plaster, wood, linoleum and other similar materials used in building construction.

The one radiator of greatest importance to mankind is our sun (Fig. 5). The sun radiates energy in all directions. A very small portion reaches our earth; after having passed through about 93,000,000 miles of space, which has a temperature of — 460 F, it delivers heat to the earth at a rate of about 360 Btu per sq ft per hr on a surface at right angles to the sun's rays. A part of the sun's energy is absorbed by the molecules of the air and by the dust particles in the air; the remainder reaches the earth. The radiation coming to the earth from the sun varies in wave length over a range which includes light radiation and heat radiation and extends somewhat on either side of those two groups.

Just as every point in the surface of the sun radiates energy, so do all points in the surfaces of the floor, walls, and ceiling of our buildings (Fig. 6). If the temperature of the ceiling of a room is higher than the mean temperature of the floor and walls, the ceiling will be a heating surface for the room (Fig. 7) but if the temperature of the ceiling is lower than the mean temperature of the floor and walls, the ceiling will be a cooling surface for the room (Fig. 8).

Advantages of Panel Warming

The method of heating buildings by means of warm panels in the ceilings, floors or walls is called *panel warming* or *radiant heating*.

The following advantages are claimed for the panel warming system by its advocates—

1) The radiators are out of sight and do not occupy floor space which can be used for other purposes.

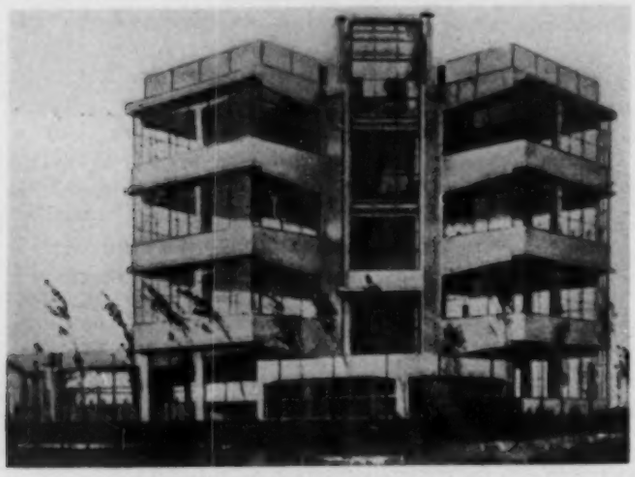
2) When the structural frame of a building has been completed, the heating system has also been completed and heating can be begun immediately to facilitate completion of interior work.

3) The heating system does not affect the location of partition walls or later changes of such walls.

4) When used in prisons or asylums, the system cannot be tampered with by the inmates.

5) The system can be used for cooling as well as for heating in those localities where the humidity is not too high.

6) The floors are warmer than in buildings heated by more ordinary systems and cold air currents along the floors are less intense.



Open air school in Amsterdam heated by radiant type system

7) Air currents within the room are materially reduced so that dust particles, to which disease producing organisms may be attached, can settle out, thereby producing a purer and more sanitary air within the building.

8) The first cost of the system depends largely on labor costs and will not vary much from that of the ordinary heating systems.

9) The cost of operating the system is somewhat lower than that of the ordinary system for the following reasons: (a) For equal comfort, the temperature of the air within the building is slightly lower and hence the cost of heating the air which passes through the building is lower; (b) the heat loss through outside walls is somewhat lower, especially when the windows have double glazing; (c) when either water or air is used as the heating medium, lower temperatures are used than in ordinary heating systems and therefore an economy in fuel combustion can be effected.

In radiant heating systems the heating panel may be situated entirely or partly on the ceiling, floor or walls. The heating medium may be water, steam, air or electricity.

In radiant cooling systems, the cooling panel should be situated in the ceiling except in operating rooms where panels should be in the walls and ceiling; cooling panels in the ceiling effect a general cooling of the entire room and those in the wall affect primarily the operating surgeon and his assistants. The cooling medium may be water or air.

Fundamentals of Design

Before undertaking the design of a radiant heating or cooling system, the following fundamentals should be considered: When two plane surfaces (Fig. 9) of considerable size are parallel and near each other and maintained at different absolute temperatures, T_1 and T_2, the heat transferred by radiation from the warmer to the cooler surface may be calculated by the equation

$$Q = 0.156 \left[\left(\frac{T_1}{100} \right)^4 - \left(\frac{T_2}{100} \right)^4 \right] \quad [2]$$

because the energy radiated by either surface may be calculated by Equation 1. For example if the temperatures of the two surfaces are 120 F and 70 F, respectively, the flow of heat by radiation from the warmer to the cooler surface will be at the rate of about 53 Btu per sq ft per hr.

If the two surfaces shown in Fig. 9 represent the ceiling and the floor of a room, Equation 2 cannot be used to calculate the transfer of heat by radiation from one to the other (except very approximately), especially if the room is small and the ceiling high, because a large part of the energy radiated by the floor and by the ceiling is radiated to the walls, and the remainder only goes to the ceiling or floor.

However, when one surface is entirely enclosed by another surface (for example Fig. 10, where a horizontal steam pipe is used to heat a room) the heat transmitted by radiation from the steam pipe to the walls, floor, and ceiling can be calculated accurately by Equation 2 if the temperatures T_2, T_3, T_4 and T_5 of the ceiling, walls, and floor are all equal.

If these temperatures are not equal, and do not differ materially from each other, it is sufficiently accurate to use their *mean value*, which is calculated by multiplying the area of each surface by its temperature and then dividing the sum of the resulting products by the sum of the surface areas. The resulting quotient is the mean temperature and is called the *mean radiant temperature* of the room. For example, if a 2 in. steam pipe is used to heat a room when the mean radiant temperature of the room is 70 F and the temperature of the pipe is 220 F, heat will be transferred from the pipe to the room by radiation at the rate of about 210 Btu per sq ft per hr. However, convection currents will be set up which transfer additional heat from the pipe to the room at the rate of about 190 Btu per sq ft per hr. (See The Cooling of Water in Iron Pipes, by F. E. Giesecke, HEATING, PIPING AND AIR CONDITIONING, August, 1929, pp. 267-272).

If the temperatures of one or more of the surfaces differ materially from the remaining temperatures, the *MRT* should be calculated by multiplying the several areas by the fourth power of their respective absolute temperatures and dividing the sum of the products by the sum of the areas; the fourth root will be the required absolute temperature.

When the ceiling is used as the heating surface of a room, one may assume that the surface of the ceiling is entirely enclosed by the surfaces of the walls and floor, and one can then calculate with sufficient accuracy by means of Equation 2 the heat transferred by radiation to the room from the ceiling, by using the ceiling surface temperature as T_1 and the mean radiant temperature of floor and walls as T_2.

For example (Fig. 11) the assumed surface temperatures are ceiling 100 F, floor 72 F, inside walls 70 F, outside wall 60 F, glass 30 F. The floor area is 180 sq ft; the inside wall areas are 150, 120, and 120 sq ft; the outside wall area is 150 sq ft (including glass); and the glass area is 20 sq ft. The ceiling area is of course 180 sq ft. The mean radiant temperature of the floor and walls therefore is $[72 \times 180 + 70\ (150 + 120 + 120) + 60\ (150 - 20) + 30 \times 20] \div 720$ or 67.6.

The heat transmitted *by radiation* from the ceiling to the room is then

$$Q = 180 \times 0.156\left[\left(\frac{560}{100}\right)^4 - \left(\frac{527.6}{100}\right)^4\right] = 5860 \text{ Btu per hr}$$

Convection Currents

When a room like that shown in Fig. 11 is heated by means of a warm ceiling, air convection currents are produced within the room which transmit additional heat from the ceiling to the room as one can readily see from Fig. 12 and from the following explanation: Since every point of the ceiling radiates energy, and since the intensity of this radiation varies inversely as the square of the distance, it is evident that the corners of the floor receive the least, and the center of the floor the largest, quantity of energy—and that therefore the floor is warmest in the center and coolest at the corners and that the temperature of the floor varies somewhat as the ordinates of the double curved surface sketched in on Fig. 12. As a result of this temperature variation, a current of warm air will rise from the center of the floor to the ceiling, spread along the ceiling in all directions to the walls—especially toward the outside wall—and return downward along the walls and in so doing convey heat from the ceiling to the walls and the room contents.

To calculate the quantity of heat conveyed by this flow of air, it is necessary to know the film coefficient for the transfer of heat from the ceiling to the air and also the average temperature of the blanket of air in contact with the ceiling. The Heating, Ventilating, Air Conditioning Guide (published by the American Society of Heating and Ventilating Engineers) recommends a value of 1.65 for interior walls. For the ceiling it is probably less, possibly 1.0. The average temperature of the air in contact with the ceiling may be assumed to be 85 F. Using these values, one finds

$$Q = 180 \times 1.0\ (100 - 85), \text{ or } 2700 \text{ Btu per hr}$$

This calculation may be quite inaccurate because it is based on an assumed value of the film coefficient and also on an assumed value of the average temperature of the air in contact with the ceiling. It is given here primarily to indicate the procedure in such a calculation. Accurate calculations can be made only after reliable data are available from carefully conducted research. For the time being, it seems sufficiently accurate to assume that the heat transmitted from the ceiling by convection currents is equal to 50 per cent of that transmitted by radiation. In that event, the heat transmitted from the ceiling to the room shown in Fig. 11 is 5860 + 2930 or 8790 Btu per hr. If the heat loss of the room is less than 8790 Btu, it is necessary either to reduce the temperature of the ceiling below 100 F or to let the heating panel extend over only part of the ceiling.

[A second article by Dr. Giesecke will give additional information on radiant heating and cooling.]

Air Raid Shelters—

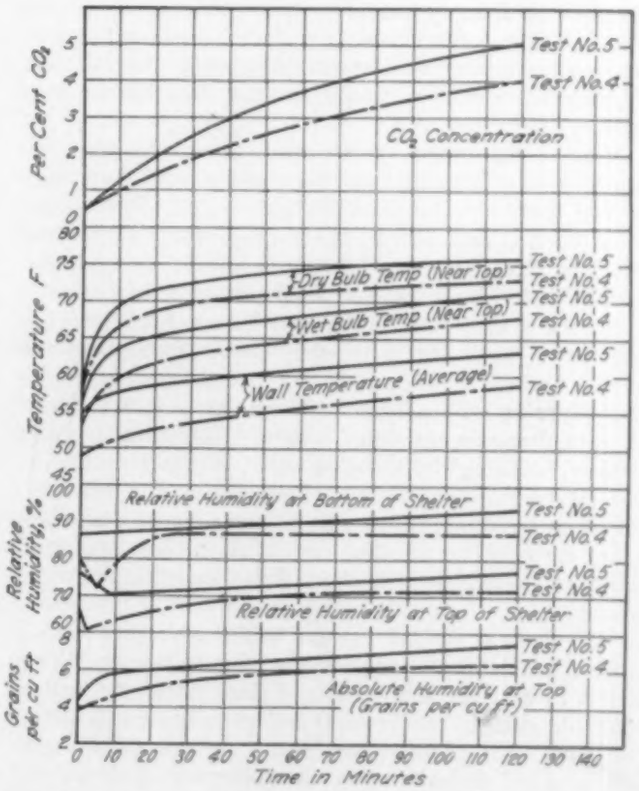
[Concluded from p. 356]

able air. It was shown for how long such unventilated shelters may be fully occupied and closed up without occasioning undue discomfort, and the rates of increase of temperature, humidity and CO_2 were recorded. Physiological observations were also made on the subjects, and their sensations recorded.

Experiments were made with various means to improve the air conditions. It was found that in a precast concrete shelter the top of which projected above grade and the whole covered with earth the CO_2 rate of increase was below the theoretical rate, this being due to diffusion through or absorption by the concrete.

In an unventilated steel shelter completely below grade and rendered gasproof, 42 persons stayed in for 1 hr without discomfort, but at the end of 2 hr some distress was evident and after 2¼ hr the CO_2 had risen to 5.2 per cent. Here there was 28.8 cu ft of space per person. It was concluded that for closed shelters, crowded and liable to be used for more than 2 hr, some form of oxygen supply with CO_2 removal, or a mechanical supply of filtered air, is essential.

Manufacturers have not been slow to appreciate these requirements and there are now on the market a number of ventilation appliances specially designed to this end. Generally these consist of a fan drawing air through beds of activated charcoal and other absorbent materials before delivering it into the shelter. Fans are electrically driven but in the event of current failure an alternative handle or a bicycle mechanism drive is provided.



Atmospheric changes in sealed shelters, when occupied. Test No. 4: Concrete shelter completely closed and sealed against gas, 1390 cu ft gross, 48 occupants. Test No. 5: Steel shelter closed and sealed against gas, 1210 cu ft gross, 42 occupants

Vertical Conversion Gas Burners

Application to Large Heating Boilers and Control

By L. S. Reagan*

THIS discussion deals with the selection and application of burners and controls for utilizing natural and mixed gas. It covers vertical conversion burners for heating boilers of the larger sizes used in industrial, commercial and institutional buildings.

During the past several years a number of manufacturers have expended considerable time and money in the development of a burner composed of a multiplicity of burner heads that discharge the heat upwardly in the firebox. Each burner head has a venturi type of mixing throat to promote efficient mixing of the air and gas.

Design of Burners

Due to the great number of types of natural and mixed gases with their widely divergent combustion characteristics, flexibility was a major design problem. It was necessary to provide for varying the discharge ports and orifice sizes to control the length of the flame and to guard against flashback in the mixing throat. This has been done in a number of different ways. One burner provides for the discharge of the gas-air mixture vertically through raised ports that are drilled to the proper size. Two others use slotted ports, also discharging vertically. A foundry technique perfected by one manufacturer allows for casting the slotted ports with tolerances close enough to eliminate machining. In the other burner the head is cast solid and the slots are cut by a milling operation.

One of the recent developments along this line is a multiple port grille that can be fabricated with any number of ports of various widths and depths. The burner head itself is cast with an open top, properly baffled and sized to receive the multiple port grille. On top of this grille is placed a refractory baffle of standard firebrick.

In the drilled port and slotted burner assemblies the discharge ports are distributed evenly throughout the entire firebox. The gas-air mixture discharges vertically, burning with a blue flame similar to that obtained from a domestic gas range burner. The multiple grille burner, utilizing the firebrick baffle, discharges the gas-air mixture around the periphery of the firebrick only. Since this discharge occurs at an angle across the secondary air openings a rapid rate of flame propagation is obtained, resulting in a short flame length at high capacity.

All of these vertical burners utilize a venturi mixing throat and quite a large amount of primary air. This tends to decrease the amount of draft necessary, makes possible a high Btu release, and provides for counteraction of back drafts without setting up a dangerous condition in the firebox due to incomplete combustion. Any of the burners described above can be provided with ports so designed and sized that there will be no flashback or burning back in the mixing tubes from 20 per cent of capacity to full capacity.

In one type of this burner, the burner heads are constructed so that any one head may be removed at any time without disturbing the balance of the assembly. The two piece type of gas spud makes it possible for the orifice size to be changed without removing the large spud base from the manifold. The material used for these parts is a non-ferrous metal, such as brass, which is not

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Summary of
Vertical Conversion Gas Burners

By L. S. Reagan

This discussion covers the application of vertical gas conversion burners and controls to heating boilers of the larger sizes as used in industrial, commercial and institutional buildings. During the past few years several manufacturers have developed a burner composed of a multiplicity of burner heads that discharge the heat upwardly in the firebox; each head has a venturi mixing throat to promote efficient mixing of air and gas. Flexibility was a major design problem due to the great number of types of mixed and natural gases, and it was necessary to provide for varying the discharge ports and orifice sizes to control flame length and guard against flashback in the mixing throat. This has been done in a number of ways. . . . Each manufacturer has developed constant burning plain pilots and safety pilots, which should be installed in accordance with the manufacturer's recommendations. . . . The burner assembly should include a balanced vane air louver to control the air admitted for combustion; this louver should have a minimum free air opening of 1 sq in. for each 12,500 Btu heat release when the operating gas pressure is 8 oz or less. . . . Specifications for a gas burner installation should include the make, type and size of boiler; maximum heat release in Btu per hr; manifold pressure of gas; type of gas; Btu per cu ft; specific gravity; gas pressure available ahead of control valves; and maximum and minimum operating steam pressure. . . . Controls include the full-on and full-off type and the floating or modulating type, the latter being used particularly where a sudden excessive demand may cause variation in line pressure and pilot failures on other gas fired appliances in the neighborhood. Three forms of modulating control diagrammed include one operating directly from steam pressure and suitable for boilers carrying pressures of 5 lb and up, one having water as the operating medium for steam pressures as low as 8 oz, and one with an adjustable cam enabling the operator accurately to synchronize gas and air flows over the load range. All these controls depend for efficient operation upon a constant draft being maintained and a draft regulator should therefore be used installed individually for each boiler or in the breeching for several boilers. A simple rule for sizing the draft regulator is that when it is to be installed in a circular duct it should have a diameter three-fourths of the duct diameter. For a rectangular duct the draft regulator should have an area 60 per cent of the duct area. . . . With properly installed burner and control equipment, average efficiencies for year 'round operation of 70 to 75 per cent have been maintained

subject to deterioration in the presence of moisture or chemicals normally present in natural gas.

All metal parts exposed to the heat of the firebox or the furnace are protected by suitable refractory material, or are made of an alloy capable of withstanding continuous exposure to the temperature attained by the combustion chamber.

Each manufacturer has developed constant burning plain pilots and safety pilots that are most suitable for his design of burner. The plain pilots are used in sufficient number to assure smooth lighting of the assembly without concussion or flashback and should be installed in strict accordance with the manufacturer's recommendations.

The safety pilot should also be installed with careful attention to factory recommendations and should be shielded so that it is not unduly affected by the draft when the burner is in operation. The safety pilot itself should be capable of igniting the entire burner assembly without the assistance of the plain gas pilots in the event of their being extinguished. Ignition will, of ourse, not be so smooth in this case as in normal operation but the safe lighting of the burner from the safety pilot only is considered a minimum safety requirement.

All pilot supply lines, both plain and safety, should be provided with cutoff cocks less operating handles, so that unauthorized persons are not likely to disturb the pilot adjustment.

The burner installation should include a suitable shut-off cock with operating handle and with indicated open and closed positions.

One of the advantages of vertical burner equipment is its low draft loss and low furnace draft requirement. The burner assembly should be so sized that the draft loss across the burner does not exceed 0.15 in. water column when the burner is operating at its maximum capacity.

The burner assembly should include a balanced vane air louver, furnished by or constructed in accordance with the burner manufacturer's recommendations, to control the admission of air for combustion. It has been determined that this air louver should have a minimum free air opening of 1 sq in. for each 12,500 Btu heat release when the operating gas pressure is 8 oz or less. The operation of the louver should not require a lift of more than ½ lb so that it can be operated with any type of automatic control valves that might be selected.

Approval of Gas Company

A point that is often overlooked when preparing specifications for a boiler and burner installation is the approval of the local gas company. It has been our experience that it is always well to furnish burner equipment that meets the approval of the gas utility. Such approval indicates that the gas company has a working knowledge of the burner equipment and assures the buyer that its service department is capable of making minor adjustments in emergency after the contractor and burner manufacturer's representative have left the job. This service is often of importance to the owner.

Along this same line, it is always well to conduct all tests to determine compliance with the specifications in the presence of the owner or his agent and a representative of the local gas company. Any points pertaining to the burner installation with which the gas company might not be familiar can be explained at the time the test is conducted.

What Specs Should Include

Specifications should be prepared in as much detail as possible for an installation, and should include such information as the following: Make, type and size of boiler. Maximum release in Btu per hr. Manifold pressure of gas in inches of water column or ounces per square inch. Type of gas. Btu per cu ft. Specific gravity. Gas pressure available ahead of the control valves. Maximum operating steam pressure. Minimum operating steam pressure.

When this information is included in the specifications it is not necessary to make any assumptions that might prove incorrect or enter into involved correspondence to determine what conditions exist on the job.

With burner equipment of the type described above, properly installed in accordance with factory recommendations, test runs can be made that will show overall efficiencies of from 73 to 78 per cent and better, according to our experience. In year 'round operation, using automatic controls, average operating efficiencies of from 70 to 75 per cent and better have been maintained.

Controls for Gas Burners

Full-On and Full-Off—The automatic control often used with gas burners in steel firebox and sectional boilers is known as the "full-on and full-off" type. With this control in the most simple form the uptake damper is set in the proper position, as determined by flue gas analysis, to allow the efficient consumption of the amount of gas necessary for the maximum load. At the command of a limit control or thermostat the burner then operates at this maximum capacity when heat is needed and shuts off completely when the demand for heat is satisfied. The first refinement to this simple arrangement is the use of air louvers for closing off the air supply when the burner is extinguished to prevent stack losses during periods of non-operation.

Fig. 5 illustrates a typical full-on and full-off control system, which, when applied to a properly designed and sized gas burner and operating with a constant draft in the furnace, will maintain an overall efficiency of 75 per cent or better, according to our experience. This constant draft can be assured by the appropriate use of a draft regulator as later discussed.

The heart of the full-on and full-off control is the automatic gas control valve, which is available in two distinct types—the quick opening and the slow opening. The quick opening valves are operated by either a solenoid or a motor and the slow opening valves by either a motor or a gas actuated diaphragm.

Experience has shown that the quick opening valves are not especially suited for inputs above 600 cu ft per hr because of the excessive ignition concussion and smothering action during the lighting cycle. It has also been our experience that the diaphragm valve is more flexible, since its operating speed may be controlled at will by adjustment of the orifice in the bleed line.

A method which permits efficient operation of the entire burner at low ratings during the fringe heating sea-

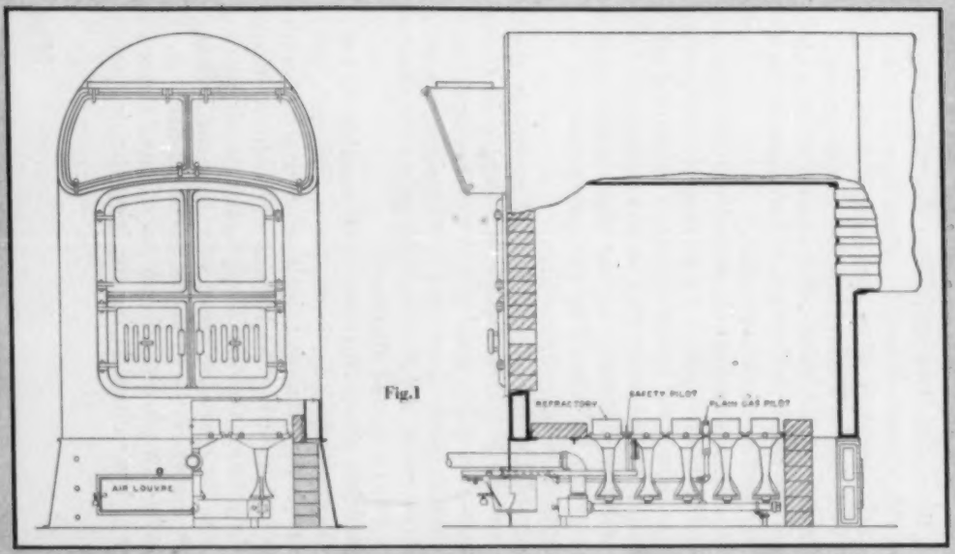


Fig.1

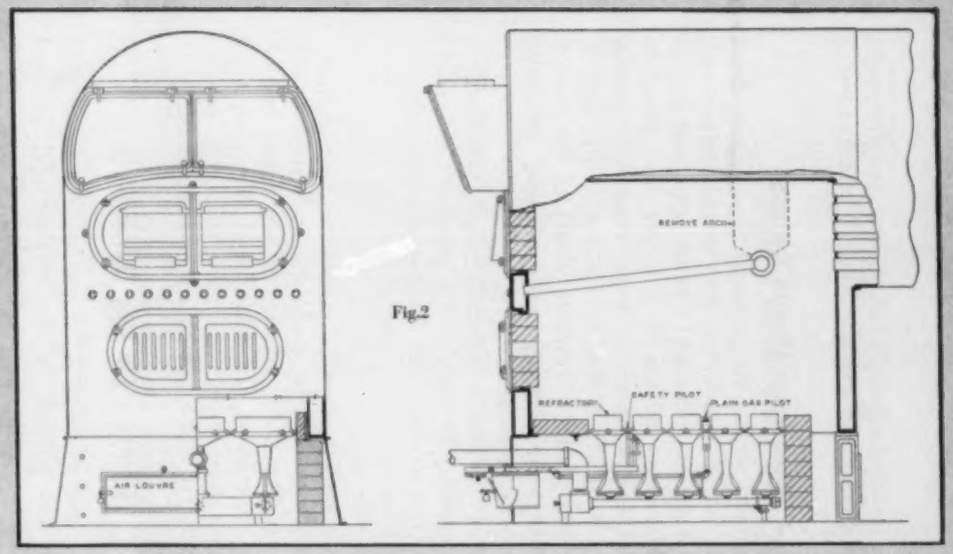


Fig.2

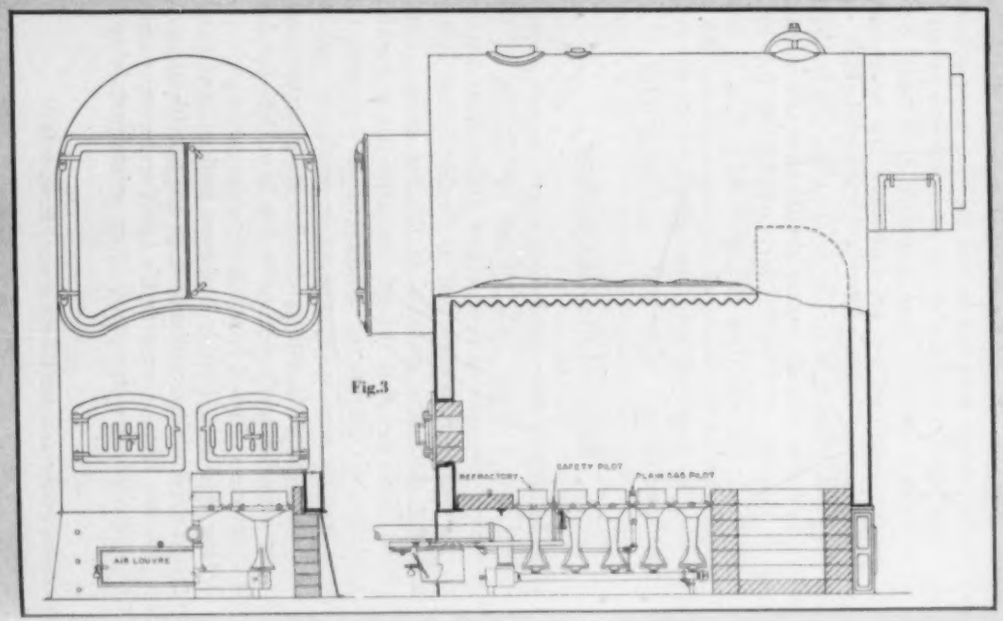


Fig.3

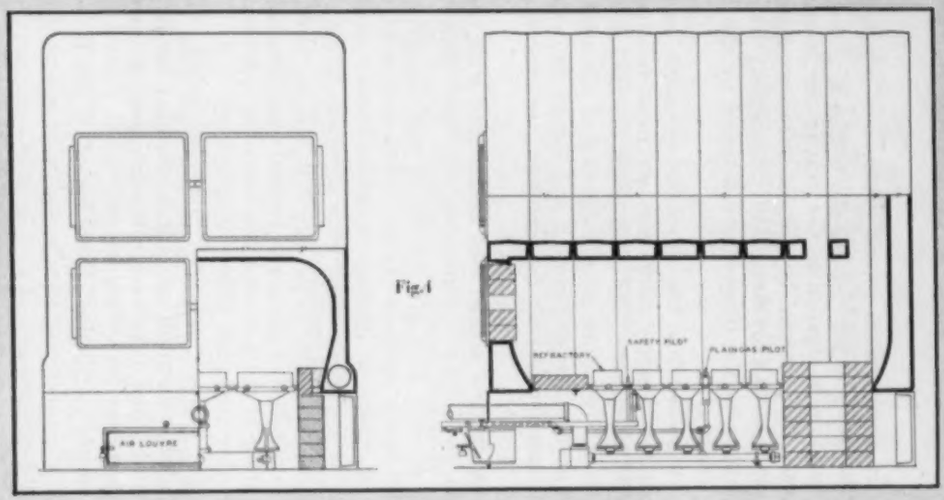


Fig.4

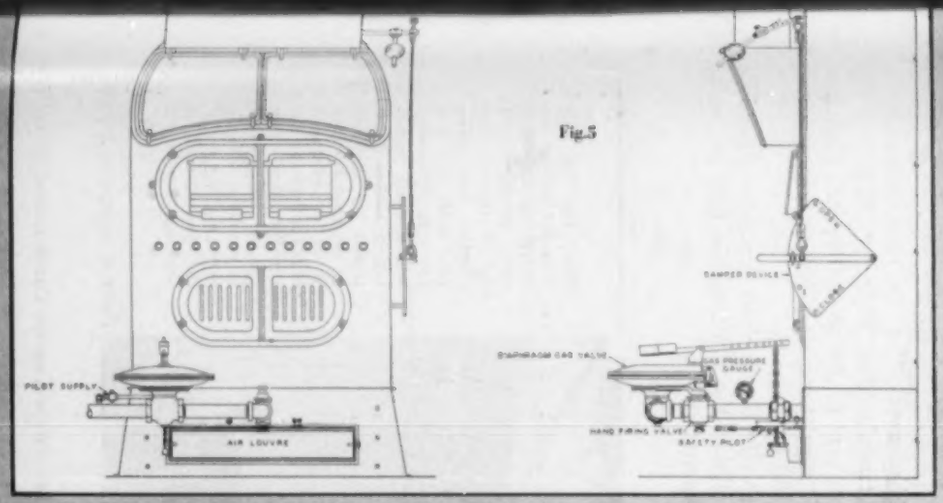


Fig.5

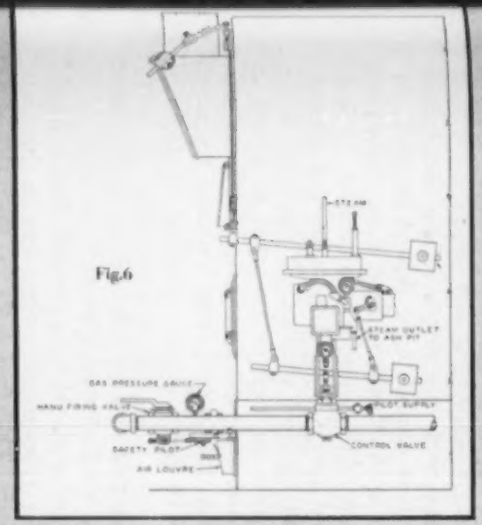


Fig.6

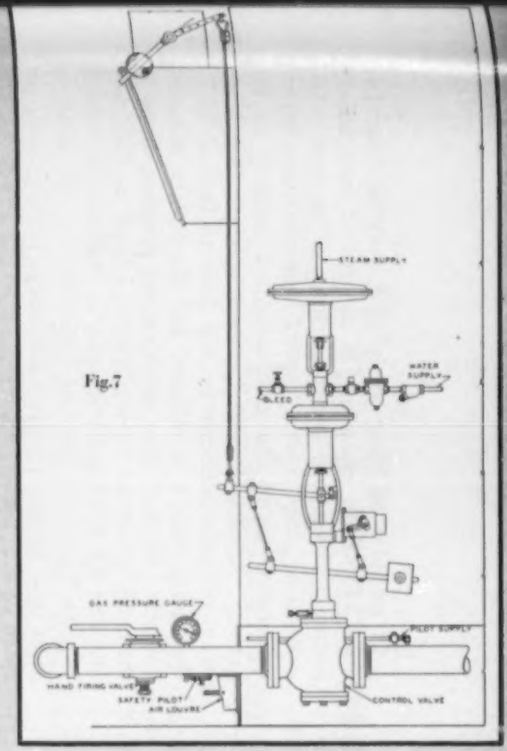


Fig.7

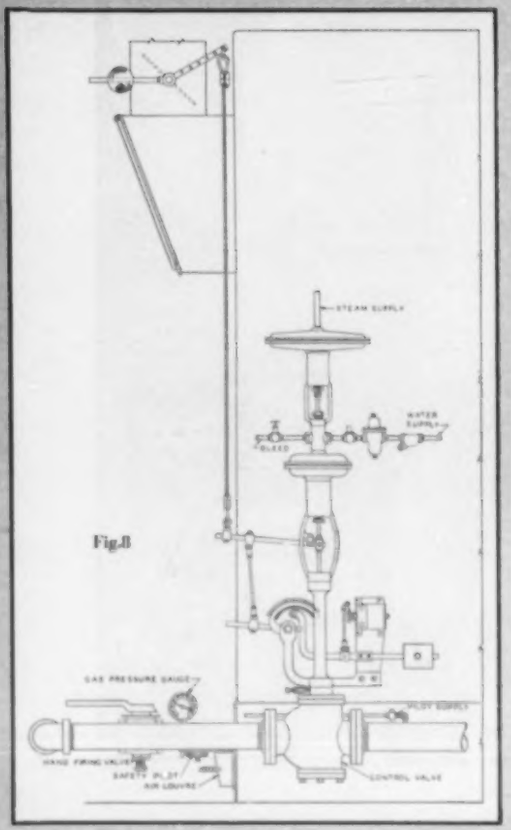


Fig.8

Fig. 1—Gas burner installation in updraft steel firebox boiler. . . . Fig. 2—Installation in downdraft steel firebox boiler. . . . Fig. 3—Gas burner installation in open bottom three pass steel boiler. . . . Fig. 4—Installation in cast iron sectional boiler. . . . Fig. 5—Typical full-on and full-off control system. . . . Fig. 6—Typical modulating control system operated with steam. . . . Fig. 7—Typical modulating control system operated with water. . . . Fig. 8—Water operated modulating control system with adjustable cam valve. . . . Fig. 9—Draft regulator installed on boiler outlet. . . . Fig. 10—Common draft regulator for an installation of two or more boilers

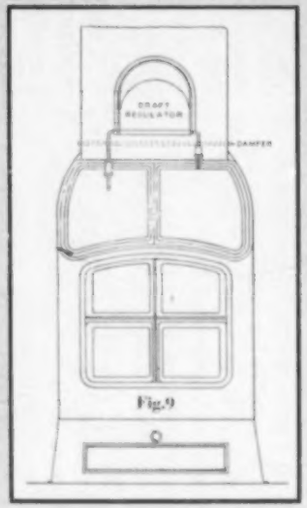


Fig.9

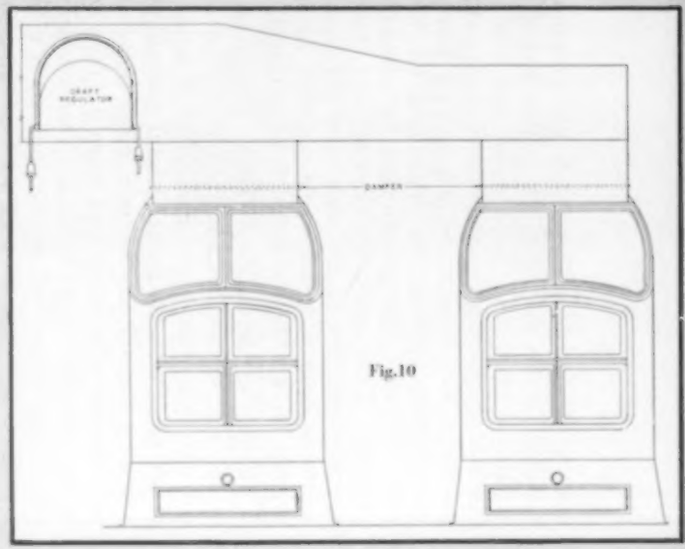


Fig.10

sons is illustrated in Fig. 5. A low pressure gage is installed in the main gas line to the burner and the damper is fitted with some device that will allow the operator to return it to any predetermined and recorded position. The damper positions and the corresponding gas pressure readings are determined for various inputs, from maximum to minimum, by means of flue gas analyses. These values are recorded on a chart and the operator can then at any time reset the equipment to whatever input he requires and maintain maximum efficiency throughout the entire heating season.

Floating or Modulating—There are cases when a boiler is so situated on a metropolitan distribution system and is of such large capacity that it is not possible to operate it with full-on and full-off control. A sudden excessive demand may cause a great variation in line pressure and pilot failures on other gas fired appliances in the immediate neighborhood. This troublesome condition may be avoided by the application of a control system of the type known as the floating or modulating control, Figs. 6, 7 and 8.

The control illustrated in Fig. 6 normally operates directly from the steam and is suitable for boilers carrying steam pressure from 5 lb per sq in. upward. By the addition of a small amount of equipment and a compressed air supply with a pressure of 15 lb per sq in. it will control steam pressures below 5 lb.

For operation at steam pressures as low as 8 oz per sq in. the equipment shown in Fig. 7 is suitable. Its operating medium is water at 15 lb per sq in. or higher, which makes it suitable for all installations.

Fig. 8 illustrates the same control as Fig. 7 except for the addition of an adjustable cam which enables the operator to synchronize accurately the gas and air flows over the entire load range. Experience has shown that the maximum hourly gas input should be in excess of 3500 cu ft before this type of equipment is warranted.

All three of the above controls have the fulcrum of the valve lever arm suspended from an arm on an electric motor. The motor is connected in series with the limit and safety controls so that in the event of failure the valve will close regardless of what position the control is in at the time. They can be made to recycle on resumption of current, or for manual resetting.

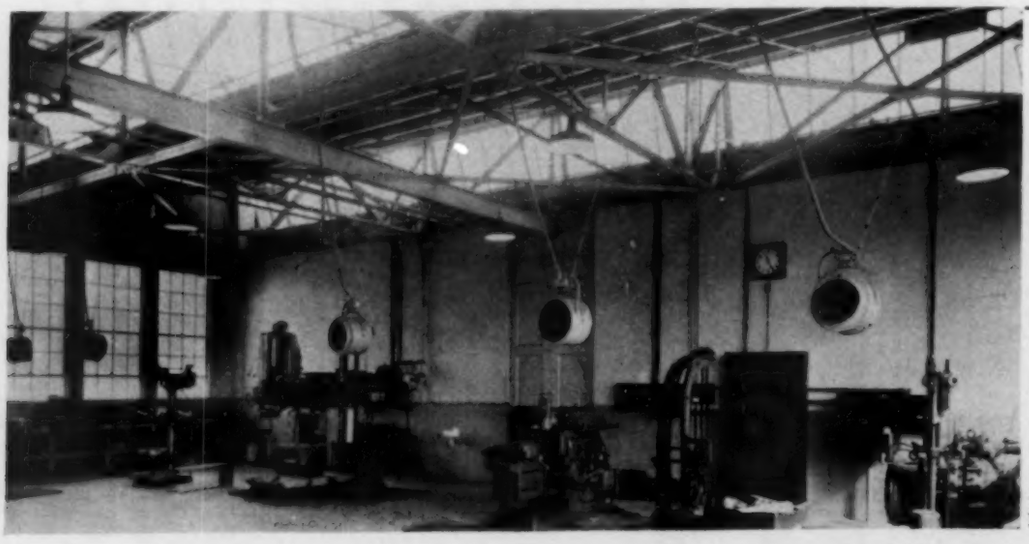
In addition to being modulating controls these last three types also make use of the full-on and full-off feature for complete cutoff at times of no load. The modulating range is set to control from maximum burner capacity down to the safe minimum capacity of the burner. After this point has been reached, should the steam pressure continue to rise (due to lack of load) the electric motor is released and the burner is extinguished. At such time as the steam pressure drops to the cut-in point the burner is again ignited, at minimum fire, and the installation is again in readiness to throttle in accordance with the load. By means of this arrangement light processing loads and fringe heating loads are taken care of automatically.

Draft Regulator Should Be Used

As is the case with the simple full-on and full-off system, all of these controls must depend for their efficient operation upon a constant draft being maintained on the stack side of the boiler uptake damper. A draft regulator should always be used to assure this constant draft during all types of weather. These may be installed individually on each boiler outlet as shown in Fig. 9. However, there are times when this is not economically feasible due to space limitations and one larger regulator must be placed in the breeching, as shown in Fig. 10.

A simple rule that may be followed in sizing a draft regulator for a particular installation is as follows: If a regulator is to be placed on a circular duct it should have a diameter approximately three-fourths the diameter of the duct. Therefore a 24 in. duct should be equipped with an 18 in. draft regulator. Since this results in a draft regulator with an area approximately 60 per cent that of the duct this 60 per cent factor can be used when making application to rectangular ducts. (*Example:* Rectangular duct 10 in. $\times$ 30 in. $=$ 300 sq in. area; 60 per cent of 300 $=$ 180 sq in. Therefore use a 16 in. draft regulator since it has an area approximately equal to 180 sq in.)

It is wise to specify that a draft regulator should be capable of maintaining the draft within 0.03 in. water column plus or minus.



Heat for the Los Angeles harbor department machine shop is furnished by 11 forced convection unit heaters, each 7.5 kw, 240 volts. This electric heating installation makes practically no increase in demand because it is so arranged that the heating circuit is opened when the air compressor is running. An interesting feature of the installation is the cable suspension

Photo courtesy Bureau of Power & Light, Los Angeles

The Psychrometric Chart

Its Application and Theory

By William Goodman*

PUBLICATION of the text of this series on the psychrometric chart was completed in April, and the first four of the appendices showing how the equations given in the text are derived appeared in the May HPAC. Publication of the appendices is continued this month.

Some of the tables of end points for wet bulb lines for various barometric pressures have already appeared and more of them are presented this month. Use of the values given in these tables was explained on p. 613 of the October, 1939, issue.

Appendix 5

Air Mixtures

Refer to Fig. 24 (p. 7, January, 1940, HPAC). When two streams of air from different sources are mixed,

$$m_1 h_1 + (1 - m_1)\, h_2 = h_3 \quad \ldots\ldots [1]$$

where m_1 = fraction of the total air in the mixture that is drawn from source 1.

Also, $m_1 w_1 + (1 - m_1)\, w_2 = w_3$ ..... [2]

From [1], $m_1 (h_1 - h_2) = h_3 - h_2$ ..... [3]

From [2], $m_1 (w_1 - w_2) = w_3 - w_2$ ..... [4]

Divide [3] by [4],

$$\frac{h_1 - h_2}{w_1 - w_2} = \frac{h_3 - h_2}{w_3 - w_2} \quad \ldots\ldots [5]$$

This is the equation of a straight line on a chart the coördinates of which are h and w.

To Prove Equation 17 of the Text:

From [2], $$m_1 = \frac{w_2 - w_3}{w_2 - w_1} \quad \ldots\ldots [6]$$

Also, $$1 - m_1 = m_2 = 1 - \frac{w_2 - w_3}{w_2 - w_1} = \frac{w_3 - w_1}{w_2 - w_1} \quad \ldots\ldots [7]$$

$$\frac{m_2}{m_1} = \frac{w_3 - w_1}{w_2 - w_3} \quad \ldots\ldots [8]$$

Now from the geometry of Fig. 24,

$$\frac{w_3 - w_1}{w_2 - w_3} = \frac{L_1}{L_2} \quad \ldots\ldots [9]$$

Also, $G_1 = m_1 G$ and $G_2 = m_2 G$ ..... [10]

where G equals total weight of air in mixture, and G_1 and G_2 equal weights of air from the two sources. Therefore, substituting [9] and [10] into [8]

$$\frac{L_1}{L_2} = \frac{G_2}{G_1} \quad \ldots\ldots [11]$$

The equations developed here are valid regardless of whether the points representing the various states of the air lie in the clear air field of the psychrometric chart or in the fogged field.

Appendix 6

Derivation of Equations 26 and 27 of the Text

Equation 4 of the text is

$$\frac{h_2 - h_1}{w_2 - w_1} = q \quad \ldots\ldots [1]$$

$$h_2 - w_2 q = h_1 - w_1 q \quad \ldots\ldots [2]$$

But, $h_2 = 0.24 t_2 + w_2 h_{g2}$ and $h_1 = 0.24 t_1 + w_1 h_{g1}$ ..... [3]

Substitute [3] into [2],

$$0.24 t_2 + w_2 h_{g2} - w_2 q = 0.24 t_1 + w_1 h_{g1} - w_1 q \quad \ldots\ldots [4]$$

Now $h_{g1} = 1061 + 0.45 t_1$ ..... [5]

and $h_{g2} = 1061 + 0.45 t_2$ ..... [6]

Subtract [6] from [5],

$$h_{g1} - h_{g2} = 0.45\,(t_1 - t_2) \quad \ldots\ldots [7]$$

$$h_{g1} = h_{g2} + 0.45\,(t_1 - t_2) \quad \ldots\ldots [8]$$

Substitute [8] into [4],

$$0.24 t_2 + w_2 h_{g2} - w_2 q = 0.24 t_1 + w_1 [h_{g2} + 0.45\,(t_1 - t_2)] - w_1 q \quad \ldots\ldots [9]$$

Symbols Used

(For complete list, see p. 358, June, 1939, HPAC)

- B_a = perfect gas constant for air, 53.34
- B_v = perfect gas constant for water vapor, 85.76
- G = weight of dry air, lb per min
- h = enthalpy of air-vapor mixture, Btu per lb of dry air in the mixture
- h_f = enthalpy of moisture in liquid state, Btu per lb of water
- h_g = enthalpy of moisture in vapor state, Btu per lb of vapor
- h_w = enthalpy of moisture in any state, Btu per lb of moisture
- L = actual length of a line on psychrometric chart, in.
- P = total barometric pressure, in. of mercury
- p = partial pressure of water vapor, in. of mercury
- Q = quantity of heat added to the air or removed from it, Btu per min
- q = moisture ratio, Btu per lb of moisture evaporated into the air or condensed from it
- T = absolute temperature, deg Fahr
- t = dry bulb temperature, deg Fahr
- t' = wet bulb temperature, deg Fahr
- v = specific volume of air-vapor mixture, cu ft per lb of dry air in the mixture
- W_w = weight of moisture evaporated into the air or condensed from it, lb per min
- w = absolute humidity of the air-vapor mixture, lb of moisture per lb of dry air in the mixture

Subscript "1" refers to the initial state of the substance and subscript "2" refers to its final state.

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*The Trane Co. Member of Board of Consulting and Contributing Editors.

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Table 8 - End Points for Wet Bulb Lines
Barometric Pressure 27 in.

Wet Bulb Temp t'	Dry Bulb Temperature, t				Absolute Humidity, w			
	For w=0		For w= 0.022	For w= 0.11	For t=40		For t= 120	For t= 450
	Over Ice	Over Water			Over Ice	Over Water		
1	2	3	4	5	6	7	8	9
-20	-18.04	-18.23						
-19	-16.93	-17.13						
-18	-15.83	-16.03						
-17	-14.71	-14.93						
-16	-13.59	-13.82						
-15	-12.47	-12.71						
-14	-11.33	-11.60						
-13	-10.20	-10.47						
-12	-9.05	-9.34						
-11	-7.91	-8.21						
-10	-6.75	-7.07						
-9	-5.58	-5.92						
-8	-4.41	-4.77						
-7	-3.23	-3.61						
-6	-2.05	-2.45						
-5	-0.85	-1.27						
-4	+0.36	-0.09						
-3	+1.57	+1.10						
-2	+2.79	+2.30						
-1	+4.03	+3.51						
0	5.27	4.72						
1	6.52	5.94						
2	7.78	7.18						
3	9.06	8.42						
4	10.35	9.68						
5	11.64	10.94						
6	12.95	12.21						
7	14.28	13.50						
8	15.61	14.80						
9	16.97	16.11						
10	18.33	17.43						
11	19.71	18.77						
12	21.11	20.12						
13	22.51	21.47						
14	23.95	22.86						
15	25.40	24.25						
16	26.86	25.65						
17	28.34	27.08						
18	29.84	28.52						
19	31.36	29.98						
20	32.90	31.45						
21	34.47	32.95						
22	36.05	34.45						
23	37.65	35.99						
24	39.28	37.54						
25	40.93	39.10			0.0001818	0.0001552		
26	42.61	40.70			0.0005119	0.0005125		
27	44.31	42.31			0.0009452	0.0008750		
28	46.04	43.95			0.001184	0.001244		
29	47.80	45.61			0.001529			
30	49.59	47.30			0.001881	0.001621		
31	51.41	49.02			0.002299	0.002004		
32	53.24	50.75			0.002599	0.002389		
33		52.53				0.002788		
34		54.32				0.003140		
35		56.14				0.003599		
36		58.01				0.004018		
37		59.89				0.004443		
38		61.80				0.004875		
39		63.75				0.005316		
40		65.73				0.005765		
41		67.74						
42		69.79						
43		71.87						
44		73.99						
45		76.17						
46		78.37						
47		80.61						
48		82.90						
49		85.23						
50		87.62						
51		90.05						
52		92.50						
53		95.01						
54		97.61						
55		100.2						
56		102.9						
57		105.6						
58		108.4						
59		111.3						
60		114.1						
61		117.1						
62		120.2					0.00004239	
63		123.3					0.0007344	
64		126.4					0.001428	

Wet Bulb Temp t'	Dry Bulb Temperature, t				Absolute Humidity, w			
	For w=0		For w= 0.022	For w= 0.11	For t=40		For t= 120	For t= 450
	Over Ice	Over Water			Over Ice	Over Water		
1	2	3	4	5	6	7	8	9
65		129.7					0.002153	
66		133.0					0.002897	
67		136.4					0.003642	
68		139.9					0.004418	
69		143.4					0.005204	
70		147.0					0.006020	
71		150.7					0.006847	
72		154.5					0.007704	
73		158.4					0.008572	
74		162.3					0.009471	
75		166.4					0.01039	
76		170.5					0.01133	
77		174.8	78.47				0.01230	
78		179.2	82.75				0.01329	
79		183.6	87.10				0.01430	
80		188.2	91.58				0.01534	
81		192.9	96.18				0.01641	
82		197.7	100.9				0.01751	
83		202.6	105.7				0.01863	
84		207.6	110.5				0.01978	
85		212.7	115.6				0.02096	
86		218.0						
87		223.4						
88		229.0						
89		234.7						
90		240.5						
91		246.5						
92		252.6						
93		258.9						
94		265.4						
95		272.0						
96		278.7						
97		285.7						
98		292.9						
99		300.2						
100		307.7						
101		315.4						
102		323.4						
103		331.5						
104		339.9						
105		348.5						
106		357.3						
107		366.5						
108		375.7						
109		385.3						
110		395.2						
111		405.2						
112		415.6						
113		426.4						
114		437.4						
115		448.7						
116							0.002112	
117							0.004555	
118							0.007052	
119							0.009629	
120							0.01233	
121							0.01508	
122							0.01799	
123							0.02086	
124							0.02384	
125							0.02699	
126							0.03023	
127					128.1		0.03355	
128					141.8		0.03697	
129					155.9		0.04057	
130					170.6		0.04426	
131					185.7		0.04803	
132					201.1		0.05190	
133					216.8		0.05594	
134					233.2		0.06017	
135					250.3		0.06447	
136					267.8		0.06896	
137					285.9		0.07365	
138					304.7		0.07850	
139					324.2		0.08344	
140					344.0		0.08855	
141					364.5		0.09385	
142					385.7		0.09950	
143					408.3		0.1051	
					430.4			

Table 9 - End Points for Wet Bulb Lines
Barometric Pressure 28 in.

Wet Bulb Temp t'	Dry Bulb Temperature, t				Absolute Humidity, w			
	For w=0		For w= 0.022	For w= 0.11	For t=40		For t= 120	For t= 450
	Over Ice	Over Water			Over Ice	Over Water		
1	2	3	4	5	6	7	8	9
-20	-18.11	-18.29						
-19	-17.01	-17.20						
-18	-15.90	-16.10						
-17	-14.79	-15.01						
-16	-13.68	-13.90						
-15	-12.56	-12.79						
-14	-11.43	-11.68						
-13	-10.30	-10.56						
-12	-9.16	-9.44						
-11	-8.02	-8.31						
-10	-6.86	-7.17						
-9	-5.71	-6.03						
-8	-4.54	-4.88						
-7	-3.37	-3.73						
-6	-2.19	-2.57						
-5	-1.00	-1.40						
-4	+0.20	-0.23						
-3	1.41	+0.95						
-2	2.62	2.15						
-1	3.85	3.35						
0	5.08	4.55						
1	6.32	5.77						
2	7.58	6.99						
3	8.84	8.23						
4	10.12	9.47						
5	11.40	10.72						
6	12.70	11.99						
7	14.01	13.26						
8	15.34	14.55						
9	16.68	15.86						
10	18.03	17.16						
11	19.40	18.49						
12	20.78	19.83						
13	22.17	21.19						
14	23.60	22.54						
15	25.02	23.92						
16	26.47	25.31						
17	27.93	26.72						
18	29.42	28.14						
19	30.92	29.58						
20	32.44	31.04						
21	33.98	32.52						
22	35.54	34.01						
23	37.13	35.52						
24	38.74	37.05						
25	40.35	38.59			0.0000 6934			
26	42.02	40.18			0.0003956	0.0000 3889		
27	43.69	41.76			0.0007228	0.0003902		
28	45.39	43.37			0.001057	0.0007406		
29	47.12	45.01			0.001396	0.001112		
30	48.88	46.68			0.001743	0.001482		
31	50.68	48.37			0.002096	0.001861		
32	52.48	50.07			0.002449	0.002240		
33		51.83				0.002632		
34		53.59				0.003027		
35		55.38				0.003430		
36		57.21				0.003841		
37		59.07				0.004260		
38		60.95				0.004683		
39		62.86				0.005116		
40		64.81				0.005557		
41		66.78						
42		68.79						
43		70.83						
44		72.91						
45		75.05						
46		77.20						
47		79.40						
48		81.64						
49		83.92						
50		86.26						
51		88.64						
52		91.04						
53		93.53						
54		96.02						
55		98.58						
56		101.2						
57		103.9						
58		106.6						
59		109.4						
60		112.2						
61		115.1						
62		118.1					0.0000463	
63		121.1					0.0009199	
64		124.2						

Wet Bulb Temp t'	Dry Bulb Temperature, t				Absolute Humidity, w			
	For w=0		For w= 0.022	For w= 0.11	For t=40		For t= 120	For t= 450
	Over Ice	Over Water			Over Ice	Over Water		
1	2	3	4	5	6	7	8	9
65		127.4					0.001635	
66		130.5					0.002339	
67		133.8					0.003075	
68		137.2					0.003832	
69		140.7					0.004597	
70		144.2					0.005399	
71		147.8					0.006190	
72		151.5					0.007027	
73		155.2					0.007875	
74		159.1					0.008744	
75		163.0					0.009634	
76		167.0					0.01054	
77		171.2					0.01149	
78		175.4	79.13				0.01244	
79		179.7	83.37				0.01343	
80		184.2	87.72				0.01444	
81		188.7	92.20				0.01548	
82		193.3	96.77				0.01653	
83		198.1	101.4				0.01763	
84		202.9	106.1				0.01873	
85		207.9	111.0				0.01988	
86		213.1	116.0				0.02106	
87		218.3						
88		223.7						
89		229.2						
90		234.8						
91		240.6						
92		246.5						
93		252.6						
94		258.9						
95		265.2						
96		271.8						
97		278.5						
98		285.4						
99		292.5						
100		299.7						
101		307.2						
102		314.8						
103		322.7						
104		330.8						
105		339.0						
106		347.5						
107		356.3						
108		365.2						
109		374.5						
110		383.9						
111		393.6						
112		403.6						
113		413.9						
114		424.5						
115		435.3						
116		446.5						
117								0.001631
118								0.004030
119								0.006493
120								0.009078
121								0.01172
122								0.01440
123								0.01722
124								0.02017
125								0.02314
126								0.02620
127								0.02935
128					138.6			0.03268
129					152.3			0.03601
130					167.0			0.03961
131					181.7			0.04321
132					196.4			0.04681
133					212.1			0.05048
134					228.6			0.05472
135					245.0			0.05877
136					262.4			0.06308
137					280.2			0.06750
138					298.6			0.07208
139					317.4			0.07676
140					336.9			0.08161
141					357.2			0.08664
142					378.2			0.09194
143					399.7			0.09734
144					421.8			0.1029
145					445.0			0.1087

Summary of

The Psychrometric Chart
Its Application and Theory

By William Goodman

Publication of the text of this series on the psychrometric chart and its application and theory was completed in the April issue. Therefore, the appendices are now presented; these show the derivation of the various equations which have appeared in the text sections. Additional tables of end points for wet bulb lines for various barometric pressures are also given this month; some of these tables have been published previously and more are to appear later. . . . . The series of which this installment is a part has included new psychrometric charts for the low, medium and high temperature ranges, discussion of the theory underlying them, and instructions and supplemental data for solving problems in practice

Clearing and rearranging terms, equation 26 of the text is obtained.

$$(0.24 + 0.45w_1)\,(t_1 - t_2) = (h_{g2} - q)\,(w_2 - w_1) \quad \ldots\ldots [10]$$

Equation 5 of the text is

$$\frac{Q}{W_a} + h_a = q \quad \ldots\ldots [11]$$

If the process is adiabatic,

$$Q = 0 \quad \ldots\ldots [12]$$

Therefore, [11] reduces to

$$q = h_a \quad \ldots\ldots [13]$$

Substituting [13] into [10], equation 27 of the text is obtained.

$$(0.24 + 0.45w_1)\,(t_1 - t_2) = (h_{g2} - h_a)\,(w_2 - w_1) \quad \ldots\ldots [14]$$

In this equation h_{g2} is taken, of course, at the temperature of the vapor, and this is the same as the dry bulb temperature of the air with which it is mixed. For the derivation of equation 25 of the text from equation 14 above, see the paragraphs immediately following equation 27 of the text.

Appendix 7

Derivation of Equation 36 of the Text

The partial pressure of the air in a humid mixture of air and moisture is less than the total barometric pressure by the partial pressure of the vapor. Hence, the perfect gas equation for the air in the mixture is

$$(P - p)\,v = B_a T \quad \ldots\ldots [1]$$

The weight of moisture in a mixture of air and water vapor is

$$w = \frac{B_a}{B_v}\,\frac{p}{P - p} \quad \ldots\ldots [2]$$

Eliminating p between [1] and [2] and clearing,

$$T = \frac{Pv}{B_a + B_v w} \quad \ldots\ldots [3]$$

$$t = \frac{Pv}{B_a + B_v w} - 459.7 \quad \ldots\ldots [4]$$

Equation 3 of Appendix 8 is

$$h = (0.24 + 0.45w)\,t + 1061w \quad \ldots\ldots [5]$$

Substituting [4] into [5] and rearranging terms,

$$h = \frac{0.24\,Pv}{B_a + B_v w} + \frac{0.45\,wPv}{B_a + B_v w} + 854w - 110.4 \quad \ldots\ldots [6]$$

Differentiating [6] with respect to w with all other terms remaining constant, and rearranging terms,

$$\frac{dh}{dw} = q = \frac{0.0399\,Pv}{B_v\,(0.622 + w)^2} + 854 \quad \ldots\ldots [7]$$

where $\dfrac{B_a}{B_v} = \dfrac{53.34}{85.76} = 0.622$

In equation 7, P is in lb per sq ft. To convert to inches of mercury, the constant 0.0399 must be multiplied by (0.4912 × 144). Also, $B_v = 85.76$. Making the necessary changes, [7] reduces to

$$q = \frac{0.0329\,Pv}{(0.622 + w)^2} + 854 \quad \ldots\ldots [8]$$

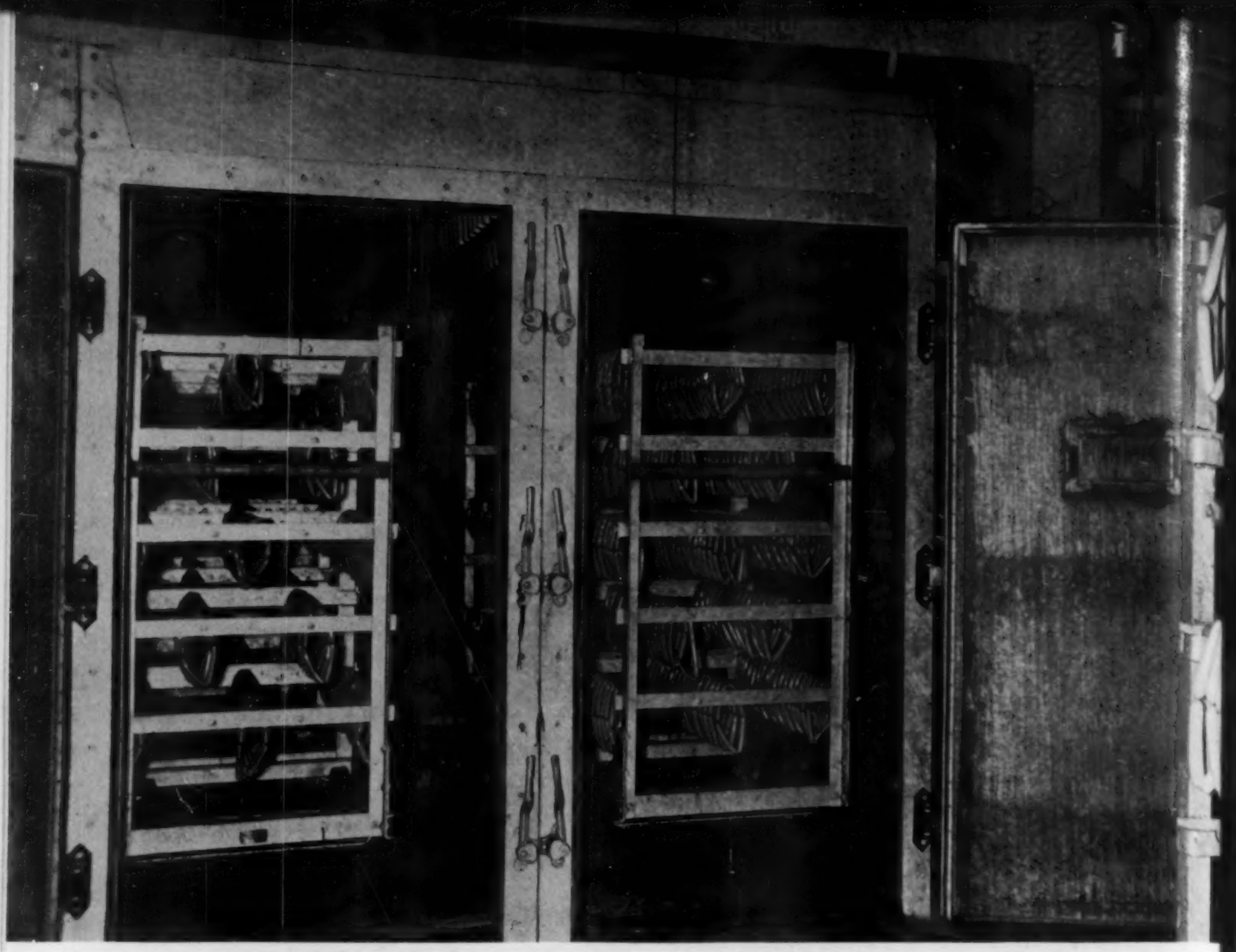
in which P is the total barometric pressure in inches of mercury, and v is the specific volume of the air-vapor mixture in cubic feet per pound of dry air in the mixture.

[To be continued]

Air Conditioning an Essential in Many Industrial Processes

● Air conditioned gold beating rooms have solved the problem of a uniform gold leaf product for Hastings and Co., Philadelphia, Pa., one of America's oldest gold beating firms. Formerly, due to adverse weather conditions, the gold leaf tended to be uneven when pressed between skins. Gold beating is still done by hand at the Hastings plant. The gold leaf is hammered out between skins in "books," consisting of approximately 100 skins each. Variations of moisture in these skins prevented the gold from being beaten evenly through the skin. Air conditioning equipment, designed to maintain the temperature at 80 F and the relative humidity at 50 per cent regardless of outside conditions, was found to solve the problem.

● Manufacture of nylon yarn and hosiery from coal, air and water—opening frontiers for a new industrial empire in America—has been made possible by the accurate control of temperature and humidity. Complicated chemical processes employed in the manufacture of both the nylon yarn and the nylon hose demand absolute accuracy in the control of the atmosphere. The "freezing" of the tiny molten filaments into permanent form after striking cool air is the secret of nylon. At the du Pont company's nylon plant at Seaford, Dela., two centrifugal refrigeration machines supply 1200 tons of cooling daily to the air conditioning system which provides one of the exacting "controls" essential to the chemical process.



An air conditioned smoke house, with doors open to show finished product. Note difference in color of finished product in house as compared with product on outside ready to be placed in the smoke house for processing when other trucks are removed

Better Product by Air Conditioning

Principles of Air Conditioning Improve Meat Products

By O. F. Gilliam*

THE smoke house, which for many years has been employed in the meat packing industry for finishing the cure and smoking of meat products, is classified in the air conditioning industry as a *dryer*. However, as are all dryers, this is a special application. The main difference in this particular dryer is that in addition to the function of drying and application of heat for curing, smoke has to be added and maintained at fairly high densities in controlled quantities. The extreme accuracy which is required in producing excellent qualities of meats in smoke houses has put a demand on the air conditioning industry to apply air conditioning principles to smoke houses or "smoke ovens," as they are often called.

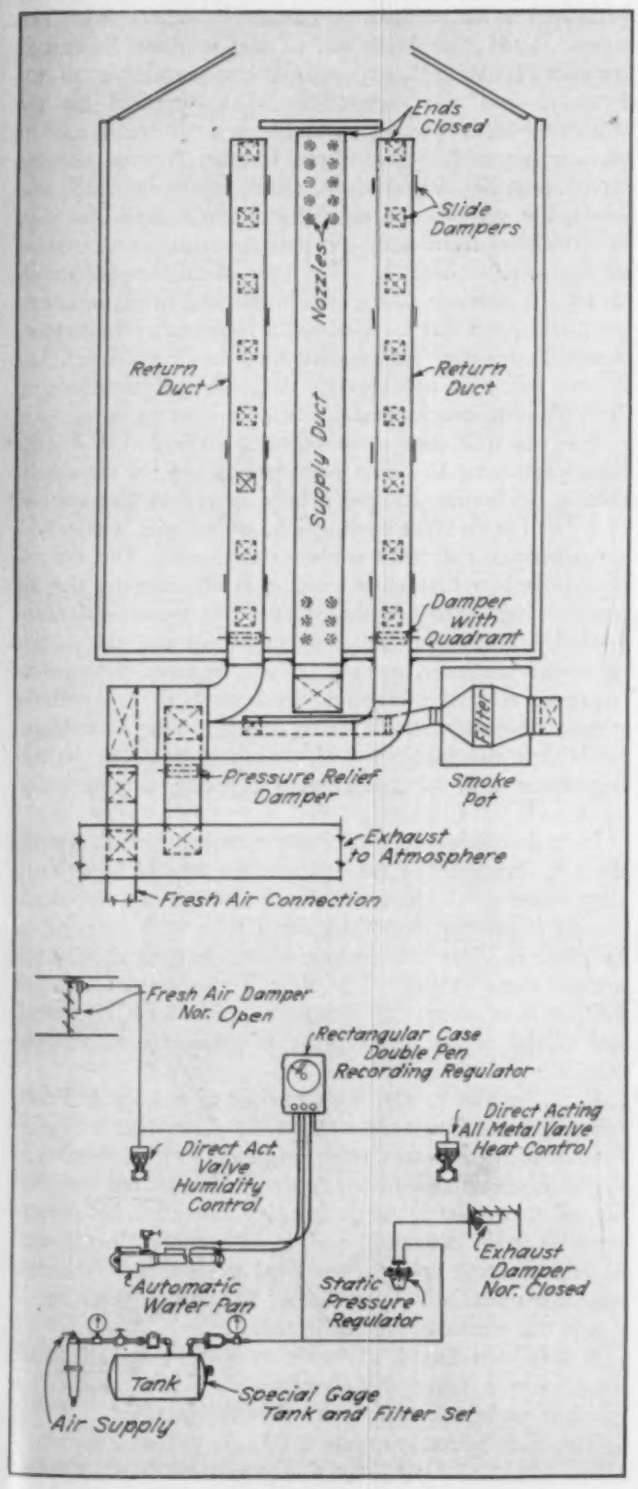
The early applications of air conditioning principles were to existing smoke houses built of brick, which meant a heavy mass of material to heat and cool. Experiments on these houses showed that high temperatures of air delivered to the smoke house were necessary to overcome the building losses, especially where outside exposures occurred. Tests made on these applications showed that a 70 deg difference was often necessary; a house processing meats which required a finishing temperature of 170 F required an air supply to the house of 170 plus 70 or 240 F. These high temperatures often proved to be detrimental to the product in the house.

As a result of these experiences, insulated panel board smoke houses have been used. These are constructed of 16 ga galvanized sheets on the inside and 20 ga galvanized sheets on the outside, formed into panels and insulated with materials 2 in. thick. These panels are put together with strips and joints which can be tightened to be sure that no leaks occur. They are flexible and can be tightened or adjusted at any time after installation has been made. The doors are placed in heavy

*District Manager, Niagara Blower Co.

galvanized frames, and swing on three heavy hinges. Three latches are used so the doors can be drawn tight against a double seal. These houses are tightly constructed to insure against any outward leakage of smoke and conditioned air. This principle of construction insures a minimum of heat loss, permitting a lower temperature of the air supplied to the smoke house. As an example, a product which finishes at an internal temperature of 142 F can be handled with a house temperature of 158 F and a temperature of the air supplied of 188 F, or a 30 deg difference. The houses are made with suitable supply and return air openings which are sealed smoke tight after the supply and return ducts are installed.

Above—Plan of smoke house showing supply and return ducts. Below—Automatic control for an air conditioned smoke house



Humidity is an important factor in smoke houses, and different products require different percentages of it. Also, the same product may require different humidities at various times during the processing.

The results with any dryer depend largely on the all important factors of air circulation and distribution. Air is the mechanical carrier of heat, moisture and smoke to and from the product which is being treated. Unless air is circulated uniformly over the product in the smoke house, non-uniform results will surely occur, causing damaged materials, delays in operation, often the expense of reprocessing, and usually an inferior product as the final result.

The distribution of air in the smoke house is accomplished by running the supply duct the full length of the house at the top, blowing down and in the center, with the cages or trees on each side. The air is discharged downward at high velocities, which draws into circulation the entire volume of air within the smoke house. The air is discharged into an open area and the aim is to produce the ejector effect without direct high velocity of air impinging on any of the product. The air discharged through the high velocity header is only about one-third of the air actually in circulation in the smoke house. In addition to producing uniform air circulation this system has other advantages; due to the comparatively small volume of air actually handled by the fan, extreme compactness in heaters and other equipment is obtained.

The temperature, and the moisture and smoke content of the air delivered through the high velocity header, is different from that which passes over the product. The process is one of dilution. The small amount of air supplied to the smoke house carries the required amount of heat, moisture and smoke to bring the entire volume of the room to the desired condition.

Fans, heaters, smoke pot, and humidifying equipment are situated outside of the oven, allowing all the space in the oven for product and eliminating the danger of damaging product through adjacent steam coils or steam lines, sprays and dirty smoke. The complete equipment consists of a panel board smoke house of the proper size to suit the individual need, heater coils, supply fan, exhaust fan, smoke pot, supply and return ducts, and automatic control. The control includes a two pen recorder-controller for recording and controlling wet and dry bulb temperatures in the smoke house, a static pressure regulator for relieving the excess pressure on the house through an exhaust duct, an outside air damper and motor operated automatically and a steam spray and automatic valve also operated from the two pen recorder-controller.

The cycle of operation is simple and automatic. The recorder-controller is set at the predetermined wet and dry bulb temperatures. With the fans in operation the air is drawn over the heater coils to heat to the proper degree of temperature. A duct connects the smoke pot to the inlet of the fan between the heater coils and the suction side of the fan. The density of the smoke is controlled by a damper in the duct about 1 ft from the smoke

Summary of

Better Product by Air Conditioning

By O. F. Gilliam

The smoke house—or smoke oven—used for many years in the meat packing industry for finishing and curing meat products is classified in the air conditioning industry as a *dryer*. As are all dryers, it is a special application; in addition to the function of drying and application of heat for curing, smoke must be added and maintained at fairly high densities in controlled quantities. . . . . The author describes the construction of modern smoke houses employing the principles of air conditioning, the temperature requirements, air distribution and circulation, and method of automatic control. He concludes by summarizing the advantages of the method. . . . . This article is another of the many which have appeared in HEATING, PIPING AND AIR CONDITIONING since May, 1929, showing how air conditioning serves almost every type of industry and manufacturing process

producing apparatus. The heated air and smoke are drawn into the fan, discharged into the supply duct to the high velocity supply header and delivered to the smoke house. Two return ducts are employed, returning the air from the house after it has done useful work, bringing it again over the heater coils to be reheated and after reheating, reconcentrated with smoke. This cycle is repeated.

If the house is too dry the recorder-controller causes the steam valve on a humidifier to become energized and opens to allow moisture in controlled amounts to be admitted to the house. In case too much humidity is built up in the house the recorder-controller will cause the humidifying valve to close, and open the outside air intake to take in dry outside air, heating it and supplying it to the house for dehumidifying.

Tests have shown that product can be finished in such a house, using hams as an example, with a variation in internal temperature of the ham of not more than 2 F where the hams do not vary more than 2 lb in weight. This variation in temperature is traceable to the difference in weight, because every test showed that light hams finished with higher temperatures and the heavy hams with lower temperatures. Product having a wider variation in weight than 2 lb had a difference in finishing temperature of 6 F. This was the widest variation recorded.

In addition, the following advantages of the air conditioned smoke house are indicated: better, more uniform and lasting color; product finishes more uniformly; savings in shrink due to close control of temperature and humidity; cleaner product due to clean smoke admitted to oven; automatic control of conditions in smoke oven; conditioned oven not affected by atmospheric conditions; saving in space requirements and cost of building construction; entire operation completed on one floor; elimination of fire hazard.

District Heating Association Holds Meeting at French Lick

The committee reports presented at the annual meeting of the National District Heating Association held last month at French Lick, Ind., included a number of items of general interest.

The research committee (G. K. Saurwein, chairman) report included a discussion of standardization of the degree day, by S. S. Sanford and A. W. Wieters, devoted to clearing up confusion which has arisen because of variations in the methods of calculating degree days. The report stated that inasmuch as the weather bureau is considered the authority in matters pertaining to the weather, that the degree day data supplied by the weather bureau should be considered as standard. It was recommended that where weather bureau stations report monthly degree days, these values be used, and where the stations do not report degree days that they be calculated from daily mean temperatures as reported by the weather bureau. (By daily mean temperature is meant the average of the maximum and minimum temperatures for a day). Use of the degree day in connection with summer air conditioning was considered, but it was felt that not enough data are yet available to draw definite conclusions.

The research committee report also included discussions pertaining to steam jet refrigeration for air conditioning. Thomas Ravese briefly described the control of a 140 ton comfort cooling job, comprising a standard three booster unit with surface condenser. The control is arranged so that when cooling is required by the air conditioning system, a dew point thermostat will automatically start the evacuating equipment and the pumps in proper sequence, turning on one or more boosters as required, after the vacuum has been built up, entirely without the attention of the operator. This installation establishes the feasibility of operating a steam jet refrigeration unit of considerable capacity automatically, he stated.

In a discussion of city water problems in air conditioning, Richard E. Hull said that the cost of New York City water as condenser water for steam jet air conditioning is greater than the cost of the steam for a given installation. For this reason, efforts have been directed toward water saving. The New York Steam Corp. has 3300 tons of steam jet air conditioning load, he stated, and of this, 1100 tons represents plain city water condenser supply installations.

R. Y. Sigworth, who is supervisor of utilities at Pennsylvania State College, contributed a discussion on maintenance of thermostatic traps on radiators and riser traps to the research committee report. He pointed out that life of thermostatic traps can be increased by careful supervision in operation and maintenance. Installation of heat control and proportional orifices will increase trap life materially by reducing the steam pressure to which the elements are subjected.

It has been found advisable to inspect and clean all traps once a year; the elements should be washed in gasoline or kerosene and any defects remedied.

The distribution committee (A. A. Sellke, chairman)

[*Concluded on p.* 374]

Properties of Mixtures of Air and Saturated Water Vapor for Barometric Pressures from 22 In. to 32 In. of Mercury

By William Goodman*

Barometric Pressure 31 In. of Mercury

All tabulated values (except temperatures and pressures) are quantities per pound of dry air in the mixture.

Temp Deg Fahr	Absolute Humidity		Volume		Humid Specific Heat	1061w	Enthalpy (Heat Content)		Temp Deg Fahr	Absolute Humidity		Volume		Humid Specific Heat	1061w	Enthalpy (Heat Content)	
	Pounds	Grains	Dry Air Cu Ft	Volume Increase of Humid Air Per Cent			Water Vapor Btu	Air-Vapor Mixture Btu		Pounds	Grains	Dry Air Cu Ft	Volume Increase of Humid Air Per Cent			Water Vapor Btu	Air-Vapor Mixture Btu
t	w	w	v_D		s^p		h_V	h	t	w	w	v_D		s^p		h_V	h
1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
— 40	0.0001123	0.7862	10.21	0.01806	0.2401	0.1192	0.1172	—9.483	40	0.005015	35.10	12.16	0.8059	0.2423	5.321	5.412	15.01
— 39	.0001189	0.8323	10.24	.01911	.2401	.1262	.1241	—9.236	41	.005214	36.50	12.18	.8380	.2424	5.532	5.630	15.47
— 38	.0001260	0.8818	10.26	.02025	.2401	.1337	.1315	—8.989	42	.005422	37.95	12.21	.8711	.2424	5.752	5.857	15.94
— 37	.0001334	0.9336	10.28	.02144	.2401	.1415	.1393	—8.741	43	.005635	39.45	12.23	.9056	.2425	5.979	6.089	16.41
— 36	.0001412	0.9882	10.31	.02270	.2401	.1498	.1475	—8.493	44	.005857	41.00	12.25	.9414	.2426	6.214	6.331	16.89
— 35	0.0001493	1.045	10.33	0.02400	0.2401	0.1584	0.1560	—8.244	45	0.006090	42.63	12.28	0.9785	0.2427	6.461	6.586	17.39
— 34	.0001580	1.106	10.36	.02540	.2401	.1676	.1652	—7.995	46	.006328	44.29	12.30	1.017	.2429	6.714	6.846	17.89
— 33	.0001670	1.169	10.38	.02685	.2401	.1772	.1747	—7.745	47	.006573	46.01	12.33	1.056	.2430	6.974	7.114	18.39
— 32	.0001766	1.236	10.41	.02839	.2401	.1874	.1848	—7.495	48	.006828	47.80	12.35	1.097	.2431	7.245	7.394	18.91
— 31	.0001865	1.306	10.43	.02998	.2401	.1979	.1953	—7.245	49	.007092	49.64	12.38	1.140	.2432	7.524	7.682	19.44
— 30	0.0001972	1.380	10.45	0.03170	0.2401	0.2092	0.2065	—6.994	50	0.007367	51.57	12.40	1.183	0.2433	7.816	7.983	19.98
— 29	.0002082	1.458	10.48	.03348	.2401	.2209	.2182	—6.742	51	.007651	53.56	12.42	1.229	.2434	8.117	8.294	20.53
— 28	.0002197	1.538	10.50	.03532	.2401	.2331	.2303	—6.490	52	.007939	55.57	12.45	1.276	.2436	8.423	8.610	21.09
— 27	.0002320	1.624	10.53	.03730	.2401	.2462	.2434	—6.237	53	.008245	57.72	12.47	1.325	.2437	8.748	8.946	21.67
— 26	.0002448	1.713	10.55	.03935	.2401	.2597	.2568	—5.983	54	.008554	59.88	12.50	1.374	.2439	9.076	9.285	22.25
— 25	0.0002582	1.807	10.58	0.04150	0.2401	0.2739	0.2710	—5.729	55	0.008876	62.14	12.52	1.426	0.2440	9.418	9.638	22.84
— 24	.0002723	1.906	10.60	.04378	.2401	.2889	.2860	—5.474	56	.009212	64.48	12.55	1.480	.2442	9.774	10.01	23.45
— 23	.0002872	2.011	10.62	.04618	.2401	.3048	.3018	—5.218	57	.009554	66.88	12.57	1.535	.2443	10.14	10.38	24.06
— 22	.0003027	2.119	10.65	.04866	.2401	.3211	.3181	—4.962	58	.009912	69.39	12.59	1.592	.2445	10.52	10.78	24.70
— 21	.0003189	2.232	10.67	.05127	.2401	.3383	.3353	—4.705	59	.01028	71.94	12.62	1.651	.2446	10.90	11.18	25.34
— 20	0.0003360	2.352	10.70	0.05402	0.2402	0.3565	0.3535	—4.447	60	0.01065	74.57	12.64	1.712	0.2448	11.30	11.59	25.99
— 19	.0003540	2.478	10.72	.05691	.2402	.3756	.3726	—4.187	61	.01105	77.33	12.67	1.775	.2450	11.72	12.02	26.66
— 18	.0003726	2.608	10.75	.05990	.2402	.3953	.3923	—3.928	62	.01146	80.21	12.69	1.840	.2452	12.16	12.48	27.36
— 17	.0003921	2.745	10.77	.06304	.2402	.4160	.4131	—3.667	63	.01188	83.15	12.72	1.907	.2454	12.60	12.94	28.06
— 16	.0004129	2.890	10.79	.06638	.2402	.4381	.4351	—3.405	64	.01230	86.12	12.74	1.977	.2455	13.05	13.41	28.77
— 15	0.0004341	3.039	10.82	0.06980	0.2402	0.4606	0.4577	—3.142	65	0.01276	89.30	12.77	2.048	0.2457	13.54	13.91	29.51
— 14	.0004567	3.197	10.84	.07342	.2402	.4845	.4816	—2.878	66	.01321	92.48	12.79	2.122	.2459	14.02	14.41	30.25
— 13	.0004804	3.363	10.87	.07723	.2402	.5097	.5069	—2.613	67	.01369	95.84	12.81	2.199	.2462	14.53	14.94	31.02
— 12	.0005049	3.534	10.89	.08118	.2402	.5357	.5330	—2.347	68	.01418	99.26	12.84	2.277	.2464	15.05	15.48	31.80
— 11	.0005303	3.712	10.92	.08526	.2402	.5626	.5600	—2.080	69	.01469	102.8	12.86	2.359	.2466	15.58	16.04	32.60
— 10	0.0005577	3.904	10.94	0.08966	0.2403	0.5917	0.5892	—1.811	70	0.01521	106.5	12.89	2.443	0.2468	16.14	16.62	33.42
— 9	.0005856	4.099	10.96	.09414	.2403	.6213	.6189	—1.541	71	.01575	110.2	12.91	2.529	.2471	16.71	17.21	34.25
— 8	.0006154	4.308	10.99	.09894	.2403	.6530	.6507	—1.269	72	.01631	114.2	12.94	2.619	.2473	17.30	17.83	35.11
— 7	.0006457	4.520	11.01	.1038	.2403	.6850	.6830	—0.9970	73	.01689	118.2	12.96	2.711	.2476	17.92	18.47	35.99
— 6	.0006776	4.744	11.04	.1089	.2403	.7190	.7172	—0.7229	74	.01748	122.4	12.98	2.807	.2479	18.54	19.12	36.88
— 5	0.0007116	4.981	11.06	0.1144	0.2403	0.7550	0.7535	—0.4465	75	0.01809	126.6	13.01	2.904	0.2481	19.19	19.80	37.80
— 4	.0007464	5.225	11.09	.1200	.2403	.7920	.7906	—0.1694	76	.01872	131.0	13.03	3.005	.2484	19.86	20.49	38.73
— 3	.0007827	5.479	11.11	.1258	.2404	.8305	.8295	+0.1095	77	.01938	135.7	13.06	3.111	.2487	20.56	21.23	39.71
— 2	.0008214	5.750	11.14	.1321	.2404	.8715	.8707	0.3907	78	.02005	140.3	13.08	3.219	.2490	21.27	21.97	40.69
— 1	.0008615	6.031	11.16	.1385	.2404	.9141	.9137	0.6737	79	.02074	145.2	13.11	3.330	.2493	22.00	22.73	41.69
0	0.0009025	6.318	11.18	0.1451	0.2404	0.9576	0.9576	0.9576	80	0.02145	150.2	13.13	3.444	0.2497	22.76	23.52	42.72
1	.0009455	6.619	11.21	.1520	.2404	1.003	1.004	1.244	81	.02219	155.4	13.15	3.563	.2500	23.55	24.35	43.79
2	.0009906	6.934	11.23	.1593	.2405	1.051	1.052	1.532	82	.02295	160.7	13.18	3.684	.2503	24.35	25.19	44.87
3	.001038	7.264	11.26	.1668	.2405	1.101	1.103	1.823	83	.02374	166.2	13.20	3.811	.2507	25.19	26.06	45.98
4	.001087	7.611	11.28	.1748	.2405	1.154	1.156	2.116	84	.02454	171.8	13.23	3.939	.2510	26.03	26.95	47.11
5	0.001138	7.967	11.31	0.1830	0.2405	1.208	1.210	2.410	85	0.02537	177.6	13.25	4.073	0.2514	26.92	27.88	48.28
6	.001191	8.338	11.33	.1915	.2405	1.264	1.267	2.707	86	.02624	183.7	13.28	4.211	.2518	27.84	28.84	49.48
7	.001246	8.725	11.35	.2004	.2406	1.322	1.326	3.006	87	.02712	189.9	13.30	4.352	.2522	28.78	29.83	50.71
8	.001304	9.129	11.38	.2097	.2406	1.384	1.389	3.309	88	.02803	196.2	13.32	4.499	.2526	29.74	30.84	51.96
9	.001365	9.555	11.40	.2195	.2406	1.448	1.454	3.614	89	.02898	202.9	13.35	4.651	.2530	30.75	31.89	53.25
10	0.001427	9.988	11.43	0.2294	0.2406	1.514	1.520	3.920	90	0.02995	209.6	13.37	4.806	0.2535	31.78	32.97	54.57
11	.001493	10.45	11.45	.2401	.2407	1.585	1.592	4.232	91	.03095	216.7	13.40	4.967	.2539	32.84	34.09	55.93
12	.001561	10.93	11.48	.2510	.2407	1.656	1.665	4.545	92	.03197	223.8	13.42	5.131	.2544	33.92	35.23	57.31
13	.001630	11.41	11.50	.2621	.2407	1.730	1.739	4.859	93	.03304	231.3	13.45	5.302	.2549	35.06	36.42	58.74
14	.001705	11.94	11.52	.2742	.2408	1.809	1.820	5.180	94	.03414	239.0	13.47	5.477	.2554	36.22	37.64	60.20
15	0.001782	12.47	11.55	0.2864	0.2408	1.890	1.903	5.503	95	0.03527	246.9	13.49	5.658	0.2559	37.42	38.90	61.70
16	.001861	13.02	11.57	.2991	.2408	1.974	1.988	5.828	96	.03643	255.0	13.52	5.844	.2564	38.65	40.20	63.24
17	.001943	13.60	11.60	.3123	.2409	2.061	2.076	6.156	97	.03762	263.3	13.54	6.035	.2569	39.91	41.53	64.81
18	.002029	14.20	11.62	.3262	.2409	2.153	2.169	6.489	98	.03886	272.0	13.57	6.234	.2575	41.23	42.92	66.44
19	.002118	14.83	11.65	.3406	.2410	2.248	2.266	6.826	99	.04014	281.0	13.59	6.439	.2581	42.59	44.34	68.10
20	0.002210	15.47	11.67	0.3553	0.2410	2.345	2.365	7.165	100	0.04144	290.1	13.62	6.648	0.2587	43.97	45.80	69.80
21	.002308	16.15	11.69	.3710	.2410	2.449	2.470	7.510	101	.04280	299.6	13.64	6.865	.2593	45.41	47.32	71.56
22	.002407	16.85	11.72	.3869	.2411	2.554	2.577	7.857	102	.04419	309.4	13.67	7.088	.2599	46.89	48.88	73.36
23	.002511	17.58	11.74	.4037	.2411	2.664	2.690	8.210	103	.04564	319.5	13.69	7.317	.2605	48.42	50.50	75.22
24	.002619	18.33	11.77	.4211	.2412	2.779	2.807	8.567	104	.04711	329.8	13.71	7.556	.2612	49.99	52.15	77.11
25	0.002729	19.10	11.79	0.4388	0.2412	2.896	2.927	8.927	105	0.04863	340.4	13.74	7.799	0.2619	51.60	53.85	79.05
26	.002847	19.93	11.82	.4578	.2413	3.021	3.054	9.294	106	.05020	351.4	13.76	8.051	.2626	53.26	55.61	81.05
27	.002967	20.77	11.84	.4770	.2413	3.148	3.184	9.664	107	.05184	362.9	13.79	8.311	.2633	55.00	57.44	83.12
28	.003091	21.64	11.87	.4970	.2414	3.280	3.319	10.04	108	.05350	374.5	13.81	8.578	.2641	56.76	59.31	85.23
29	.003221	22.55	11.89	.5179	.2415	3.418	3.460	10.42	109	.05522	386.6	13.84	8.853	.2649	58.59	61.24	87.40
30	0.003356	23.50	11.91	0.5396	0.2415	3.561	3.607	10.81	110	0.05700	399.0	13.86	9.139	0.2657	60.48	63.24	89.64
31	.003498	24.48	11.94	.5623	.2416	3.711	3.760	11.20	111	.05882	411.7	13.88	9.430	.2665	62.41	65.28	91.92
32	.003640	25.48	11.96	.5850	.2416	3.862	3.915	11.60	112	.06071	425.0	13.91	9.732	.2673	64.41	67.40	94.28
33	.003793	26.55	11.99	.6095	.2417	4.024	4.082	12.00	113	.06266	438.6	13.93	10.04	.2682	66.48	69.60	96.72
34	.003949	27.64	12.01	.6348	.2418	4.190	4.252	12.41	114	.06466	452.7	13.96	10.36	.2691	68.61	71.85	99.21
35	0.004110	28.77	12.04	0.6607	0.2419	4.361	4.427	12.83	115	0.06673	467.1	13.98	10.69	0.2700	70.80	74.17	101.77
36	.004280	29.96	12.06	.6879	.2419	4.541	4.612	13.25	116	.06887	482.1	14.01	11.03	.2710	73.07	76.59	104.43
37	.004455	31.18	12.08	.7157	.2420	4.726	4.802	13.68	117	.07107	497.5	14.03	11.39	.2720	75.40	79.05	107.13
38	.004635	32.44	12.11	.7449	.2421	4.917	4.998	14.12	118	.07332	513.2	14.05	11.75	.2730	77.79	81.59	109.91
39	.004821	33.75	12.13	.7747	.2422	5.115	5.202	14.56	119	.07563	529.4	14.08	12.12	.2740	80.25	84.20	112.76

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(Tabulations for 22 in., 23 in., 24 in., 25 in., 26 in., 27 in., 28 in., 29 in., and 30 in., were published in July, August, September, October, November and December, 1939, and March, April and May 1940.)

Properties of Mixtures of Air and Saturated Water Vapor—(Continued)

Barometric Pressure 31 In. of Mercury

All tabulated values (except temperatures and pressures) are quantities per pound of dry air in the mixture.

Temp Deg Fahr	Absolute Humidity		Volume		Humid Specific Heat	1061w	Enthalpy (Heat Content)		Temp Deg Fahr	Absolute Humidity		Volume		Humid Specific Heat	1061w	Enthalpy (Heat Content)	
	Pounds	Grains	Dry Air Cu Ft	Volume Increase of Humid Air Per Cent			Water Vapor Btu	Air-Vapor Mixture Btu		Pounds	Grains	Dry Air Cu Ft	Volume Increase of Humid Air Per Cent			Water Vapor Btu	Air-Vapor Mixture Btu
t	w	w	v_D		s''		h_v	h	t	w	w	v_D		s''		h_v	h
1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
120	0.07806	546.4	14.10	12.51	0.2751	82.82	86.93	115.74	160	0.2832	1982.5	15.08	45.21	0.3674	300.49	320.08	358.48
121	.08055	563.9	14.13	12.90	.2763	85.46	89.74	118.78	161	.2933	2052.8	15.10	46.80	.3720	311.14	331.55	370.19
122	.08308	581.5	14.15	13.31	.2774	88.15	92.59	121.87	162	.3038	2126.5	15.12	48.48	.3767	322.31	343.58	382.46
123	.08574	600.2	14.18	13.73	.2786	90.97	95.59	125.11	163	.3147	2202.9	15.15	50.21	.3816	333.90	356.05	395.17
124	.08845	619.2	14.20	14.17	.2798	93.85	98.65	128.41	164	.3262	2283.1	15.17	52.04	.3868	346.05	369.14	408.50
125	0.09128	638.9	14.22	14.62	0.2811	96.84	101.85	131.85	165	0.3381	2366.6	15.20	53.94	0.3921	358.71	382.79	422.39
126	.09418	659.2	14.25	15.08	.2824	99.92	105.12	135.36	166	.3507	2454.6	15.22	55.94	.3978	372.05	397.16	437.00
127	.09718	680.3	14.27	15.56	.2837	103.11	108.51	138.99	167	.3637	2546.1	15.25	58.01	.4037	385.92	412.11	452.19
128	.1003	701.9	14.30	16.06	.2851	106.39	112.00	142.72	168	.3775	2642.8	15.27	60.20	.4099	400.57	427.90	468.22
129	.1035	724.2	14.32	16.57	.2866	109.76	115.60	146.56	169	.3919	2743.2	15.30	62.48	.4164	415.80	444.33	484.89
130	0.1068	747.7	14.35	17.10	0.2881	113.33	119.40	150.60	170	0.4070	2849.1	15.32	64.89	0.4232	431.84	461.63	502.43
131	.1102	771.5	14.37	17.64	.2896	116.93	123.25	154.69	171	.4229	2960.0	15.34	67.40	.4303	448.65	479.78	520.82
132	.1136	795.5	14.40	18.20	.2911	120.57	127.13	158.81	172	.4396	3077.2	15.37	70.06	.4378	466.42	498.95	540.23
133	.1173	821.1	14.42	18.78	.2928	124.46	131.27	163.19	173	.4573	3200.8	15.39	72.87	.4458	485.15	519.17	560.69
134	.1211	847.5	14.44	19.37	.2945	128.46	135.54	167.70	174	.4758	3330.7	15.42	75.82	.4541	504.85	540.44	582.20
135	0.1248	873.7	14.47	20.00	0.2962	132.43	139.79	172.19	175	0.4952	3466.4	15.44	78.89	0.4628	525.41	562.65	604.65
136	.1289	902.4	14.49	20.63	.2980	136.78	144.43	177.07	176	.5158	3610.7	15.47	82.16	.4721	547.29	586.28	628.52
137	.1331	931.6	14.52	21.29	.2999	141.20	149.16	182.04	177	.5376	3763.4	15.49	85.63	.4819	570.45	611.29	653.77
138	.1374	961.9	14.54	21.98	.3018	145.79	154.06	187.18	178	.5607	3924.6	15.51	89.29	.4923	594.86	637.70	680.42
139	.1418	992.7	14.57	22.68	.3038	150.46	159.05	192.41	179	.5852	4096.1	15.54	93.18	.5033	620.85	665.74	708.70
140	0.1464	1024.7	14.59	23.41	0.3059	155.31	164.24	197.84	180	0.6114	4279.5	15.56	97.33	0.5151	648.65	695.79	738.99
141	.1511	1057.5	14.61	24.17	.3080	160.29	169.56	203.40	181	.6390	4472.8	15.59	101.7	.5275	677.95	727.47	770.91
142	.1561	1092.4	14.64	24.95	.3102	165.58	175.22	209.30	182	.6686	4680.5	15.61	106.3	.5409	709.43	761.51	805.19
143	.1611	1127.4	14.66	25.76	.3125	170.87	180.89	215.21	183	.7003	4902.4	15.64	111.4	.5552	743.06	797.90	841.82
144	.1663	1164.0	14.69	26.60	.3148	176.42	186.83	221.39	184	.7341	5138.4	15.66	116.8	.5703	778.84	836.61	880.77
145	0.1717	1202.0	14.71	27.47	0.3173	182.19	193.03	227.83	185	0.7703	5392.0	15.68	122.5	0.5866	817.28	878.21	922.61
146	.1774	1242.1	14.74	28.36	.3199	188.26	199.53	234.57	186	.8089	5662.0	15.71	128.6	.6040	858.19	922.49	967.13
147	.1833	1283.0	14.76	29.29	.3225	194.47	206.18	241.46	187	.8505	5953.2	15.73	135.2	.6227	902.34	970.29	1015.2
148	.1894	1325.8	14.78	30.26	.3252	200.90	213.08	248.60	188	.8957	6269.9	15.76	142.4	.6431	950.34	1022.3	1067.4
149	.1956	1369.2	14.81	31.26	.3280	207.53	220.19	255.95	189	.9449	6614.1	15.78	150.2	.6652	1002.5	1078.8	1124.1
150	0.2022	1415.3	14.83	32.30	0.3310	214.51	227.68	263.68	190	0.9978	6984.3	15.81	158.6	0.6890	1058.6	1139.4	1185.0
151	.2089	1462.6	14.86	33.39	.3340	221.69	235.37	271.61	191	1.056	7388.5	15.83	167.8	.7150	1119.9	1205.8	1251.6
152	.2157	1510.1	14.88	34.50	.3371	228.89	243.11	279.59	192	1.119	7832.3	15.85	177.8	.7435	1187.2	1278.7	1324.8
153	.2233	1563.0	14.91	35.67	.3405	236.90	251.70	288.42	193	1.189	8323.7	15.88	188.9	.7751	1261.6	1359.4	1405.7
154	.2309	1616.0	14.93	36.87	.3439	244.93	260.33	297.29	194	1.265	8856.4	15.90	201.0	.8093	1342.4	1446.9	1493.4
155	0.2388	1671.4	14.95	38.13	0.3475	253.33	269.36	306.56	195	1.351	9454.2	15.93	214.5	0.8478	1433.0	1545.1	1591.9
156	.2470	1728.7	14.98	39.44	.3511	262.02	278.72	316.16	196	1.445	10,117	15.95	229.5	0.8904	1533.5	1654.0	1701.0
157	.2553	1787.3	15.00	40.79	.3549	270.91	288.27	325.95	197	1.552	10,863	15.98	246.4	0.9383	1646.5	1776.4	1823.6
158	.2643	1850.4	15.03	42.20	.3590	280.46	298.55	336.47	198	1.672	11,702	16.00	265.4	0.9923	1773.7	1914.3	1961.8
159	.2736	1914.9	15.05	43.67	.3631	290.25	309.07	347.23	199	1.781	12,470	16.03	282.7	1.042	1890.1	2040.6	2088.4
									200	1.963	13,744	16.05	311.5	1.124	2083.2	2249.9	2297.9

District Heating—

[*Concluded from p.* 372]

report included a paper by V. J. Suche on steam loss from an underground main and its relation to steam distribution system unaccounted-for losses. In the conclusions it was stated that line loss, or loss due to radiation only, represents about half the unaccounted-for steam. Once a system has been installed, this loss can be kept at a minimum by constant maintenance of exposed insulation and operating at as low a temperature as possible.

The other half of the unaccounted-for steam is truly unaccounted for, as it cannot be correctly allocated to each of its contributing factors. The only hope for a reduction lies in the adoption of approved metering methods when possible, and constant vigilance and maintenance for leaks, faulty safety valves and traps. Some reduction in loss can be made by carrying as low a system pressure at all times as is consistent with good service.

The feature of the commercial relations committee report was a paper on study of heating economies, by Earle Shultz and J. C. Butler. A joint report of the National Association of Building Owners and Managers and the NDHA, it covered a study of some 1000 buildings and showed the influence of various types of heating systems and of controls. (See HEATING, PIPING AND AIR CONDITIONING, October, 1939, pp. 609-612, and November, 1939, pp. 667-670, for further information about this study and tabulated results).

The report of the committee on operating statistics (W. A. Herr, chairman) concluded by summarizing the district heating highlights of the year 1939 as follows:

An increase in sales volume for most companies, with the exception of those in the Mountain and Pacific districts.

An increase in revenue and a slight decrease in average rate for practically all companies, excepting those in the Mountain and Pacific districts.

A small increase in connected load.

Cooler weather for most companies in the Eastern, Central and Southern districts.

A decrease in cost of fuel per million Btu for most of the companies.

A decrease in number of employees, a slight increase in average hourly rate and a negligible reduction in total hourly cost of labor.

A slight increase in invested capital.

Many other reports and papers were presented which, because of their specialized interest and lack of space, are not reviewed here.

The officers elected for the coming year are Fred L. Witsell, president; Leonard S. Phillips, John M. Arthur and D. C. Turnbull, Jr., vice-presidents; John F. Collins, Jr., secretary-treasurer; and R. M. Nee, J. M. Barnes and G. D. Winans, executive committee.

Heating · Piping and Air Conditioning

AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS

Journal Section

★ CONTENTS ★

JUNE, 1940

Study of Changes in the Temperature and Water Vapor Content of Respired Air in the Nasal Cavity, by Lauren E. Seeley..... 377
Dirt Patterns on Walls, by R. A. Nielsen.... 389
Applications of Gas to Air Conditioning, by George E. May..... 395
Welcome to Washington..... 400
Local Chapter Reports..... 402
Candidates for Membership..... 403
Candidates Elected 404

BULLETIN BOARD

When you wonder what to do—remember that there is always work to be done by the Society and its members: Codes to be sponsored and developed; funds to be secured for research; data to be analyzed and tabulated for everyday service; cooperative effort to establish a uniform method of heat loss calculations. These and innumerable other problems face the officers, committees, the members, and the profession at large. There is something waiting for the attention of everyone who desires to cooperate and advance the art of heating, ventilating and air conditioning.

Send in an idea for research—a suggestion for THE GUIDE—write a paper—get a new member—offer a lead for employment! This cooperation will help make your Society a better and more influential organization for service.

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Study of Changes in the Temperature and Water Vapor Content of Respired Air in the Nasal Cavity

By Lauren E. Seeley* (*MEMBER*), New Haven, Conn.

Introduction

THE project, being new, required the development of apparatus and procedures. Any experimenter will know what he is spared if an account of the development is omitted. Conceived in 1936, with preliminary work in 1937, it was not until 1938 and 1939 that what seemed like satisfactory results were obtained. The project was to measure changes in the temperature and water vapor content of respired air at certain positions in the nasal cavity with room air at various temperatures and relative humidities. The reason was a desire to discover if the control of relative humidity in occupied enclosed spaces was really important. Body heat loss studies were in general establishing the view that the condition of the air was important only as it enabled bodies to reject, without discomfort, an amount of heat equal to that evolved by body metabolism. Assuming no extremes in the humidity of air, this view is scientifically accurate for any static condition which achieves thermal equilibrium. Unfortunately, conditions are not in fact static because individuals are themselves mobile. They are going from place to place—indoors and outdoors—back and forth. They are literally passing almost instantly from one climate to another. Becoming acclimatized to daily and seasonal outdoor changes is sometimes in itself a severe process in temperate climates. Modern conditions involve subjection to changes which may induce consequences more important than is generally realized. Obviously, it is necessary to learn what actually happens to respired air in the nasal cavity before the effects of a sudden climatic change can be completely evaluated.

The following may help to unfold the problem. Cold air of moderate relative humidity will, upon being heated, have a much lower relative humidity. This happens when cold, outdoor air leaks into a heated but unhumidified structure. The cold air, upon being heated, is called *dry* and is believed by many persons to be unhealthful. Yet in heating that air the water vapor is not lost. Its density per unit volume is only reduced somewhat because the volume of air is somewhat increased due to its rise in temperature. This means that, when breathed, the water vapor per unit volume is not much different whether the above air is warm or cold.

If the air in both cases (viz., warm and cold) is heated and humidified in the nasal cavity to the same final conditions, it follows that the moisture supplied in the nasal cavity would be about the same for equal volumes of air breathed. The so-called drying of the mucous membrane would be very little more in one case than in the other. However, if the air is not heated and humidified to the same final conditions, the moisture losses in the nasal cavity would be different. The sensations associated with the *dry* atmosphere might be a definite consequence of a higher rate of moisture loss especially when suddenly imposed. Whether or not an adequate adjustment can be made eventually to an altered atmosphere would depend upon individual characteristics. Passing from the atmosphere into a heated or cooled building involves an altered atmosphere.

When heat losses from the body by radiation and convection are not sufficient then the evaporative loss from skin surfaces makes up or attempts to make up the difference. Skin surfaces are sometimes moist and sometimes not. The respiratory system is different. The surfaces therein are normally moist. These moist surfaces should be responsive to any and all changes in the water vapor pressure of inspired air regardless of whatever may be the extent of the evaporative heat loss from the external surfaces of the body. A body may be protected by clothing but the respiratory system, especially the nasal cavity, must cope with whatever air the environ-

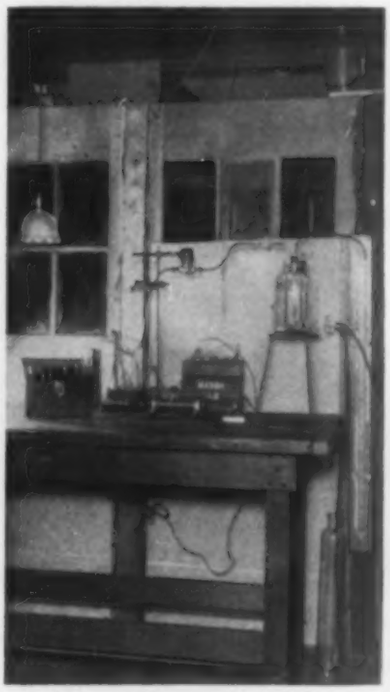

Fig. 1—Partial view of test rooms

*Assistant Professor of Mechanical Engineering, Yale School of Engineering, Yale University.

For presentation at the Semi-Annual Meeting of the American Society of Heating and Ventilating Engineers, Washington, D. C., June, 1940.

ment provides. Persons must breathe the air that surrounds them. The physiological consequences of the air inspired must be distinguished from thermal, external effects.

In Part I a brief account of experimental procedures and the results in graphical form will be given. Part II is an indulgence in the human and understandable desire to speculate upon results achieved and further work to be done. It is speculation which induces new undertakings. And presumably it is required from time to time in order to carry on.

Part I

The object of the experiments was to measure the changes in temperature and moisture content of respired air at different positions in the nasal cavity. The experiments required:

(*a*) an enclosed space with a controlled atmosphere.
(*b*) a means of securing a sample of respired air.
(*c*) measurements of said air sample to find its temperature and moisture content.

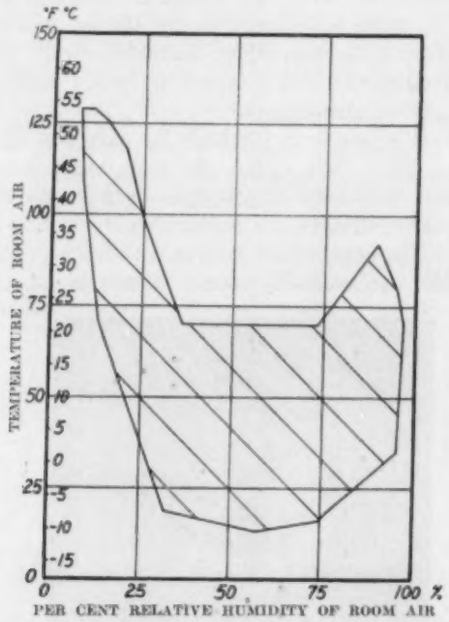

Fig. 2—Room air conditions used in the tests

In the Laboratory of Applied Physiology an enclosed space about 9 ft square and 7 ft high within a larger room was made available (see Fig. 1 for partial view). A 5 hp air conditioning unit was installed for heating or cooling the test room. A mechanically-aspirated psychrometer and an electric oven were placed in the test room. While air conditions were held nearly constant for any one series of tests the various conditions achieved were somewhere within the area shown in Fig. 2. These conditions embrace those used by the American Society of Heating and Ventilating Engineers, Dr. C.-E. A. Winslow and his associates, Dr. E. F. DuBois and others in their body-heat-loss studies.

The sample of respired air was obtained from the nasal cavity generally between the floor of the cavity and the inferior turbinate by means of a stainless steel tube ⅛ in. in diameter and about 5 in. long. Except for that portion of the tube actually inserted in the nose, the remainder was enclosed in a layer of wool covered with oiled silk. The sampling tube was perforated near the end to admit the air sample. Near the perforations, within the tube, was a copper-constantan thermocouple made of very fine wire for quick response. The couple was considered to be adequately shielded from radiation.

The sampling tube was inserted into the nasal cavity in the positions shown in Fig. 3. The positions could be duplicated by means of the adjustable stop shown below the tube. Positions were numbered 1, 2 and 3. The letter *I* was used to indicate samples taken during inspiration and *E* for samples during expiration. In addition to the above a position No. 4 (not shown) was used to indicate a test where the tube was out in the portal of the nose for the purpose of taking expired air only.

The sampling tube could be attached or detached from an electrically heated, insulated handle in which a push button valve was located. This valve was manually operated to control the time and duration of taking the sample. From the handle the air passed through an absorption tube containing anhydrous magnesium perchlorate. This substance absorbed the water vapor in the air sample. The absorption tube was placed in an insulated bag. All outside parts of the air flow system from the sampling tube to the absorption tube were either insulated or heated. The sampling tube when not in use and the absorption tubes were kept warm in an electric oven. The water vapor was not allowed to condense before the air sample reached the absorption tube. The various parts described above may be seen in Figs. 4 and 4*a*. Insulation on the tube is not shown.

After leaving the absorption tube the air, now dry, was conducted to the larger room to a collecting bottle. The air bubbled up through distilled water contained therein after passing through some carborundum saturators. These saturators break the air into tiny bubbles, and an assumption was made that the air reached the top of the bottle saturated at the water temperature. Since the bottle was in thermal equilibrium with the air of the outer room, it was difficult to see how the air sample temperature could be any different from the bottle and its contents. The volume of air collected had to equal the volume of water removed from the bottle. Either 1000 or 2000 cc of water were collected in a graduate. The pressure of the saturated air sample was measured with a manometer. Knowing the pressure, volume and temperature of the saturated air, the weight of dry air in the sample could be determined. Figs. 5 and 5*a* show the assembly above described.

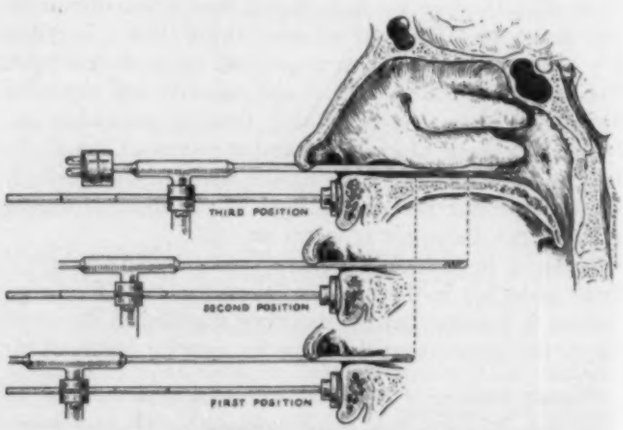

Fig. 3—Sampling tube in nasal cavity

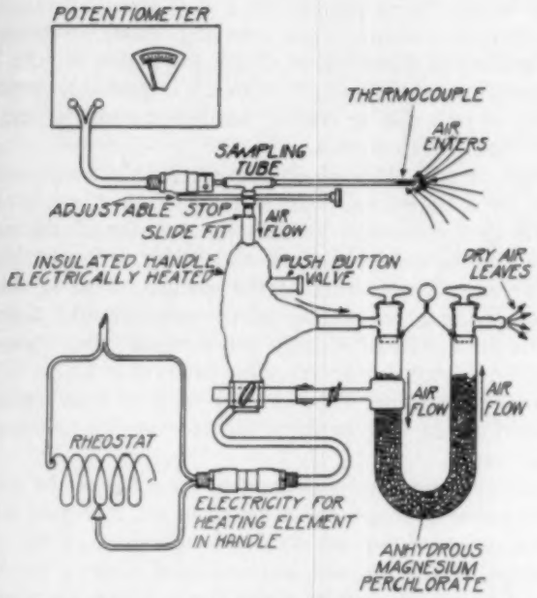

Fig. 4—Diagrammatic sketch of sampling tube and absorption tube

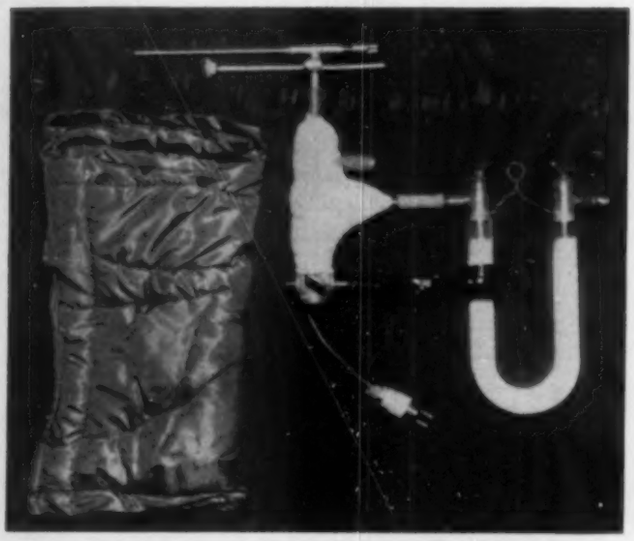

Fig. 4a—Photograph of sampling tube used with absorption tube

From the aspirating psychrometer data the weight of water per pound of room air could be calculated. The absorption tubes were weighed after reaching thermal equilibrium with the air in the room housing the balance. Corrections for change in the buoyancy of the tubes based on barometer and air temperature were made. The difference between the moisture absorbed and the moisture in the original air being breathed gave the moisture evaporated in the nasal cavity. By means of a potentiometer the temperature of the air sample from the nasal cavity was determined. From the above data the relative humidity of the air sample could be calculated.

Results of interest are as follows:

(*a*) The temperature of the air sample.
(*b*) The relative humidity of the air sample.
(*c*) The water evaporated in the nasal cavity per pound of dry air breathed.
(*d*) The sensible and latent heat of the air sample.

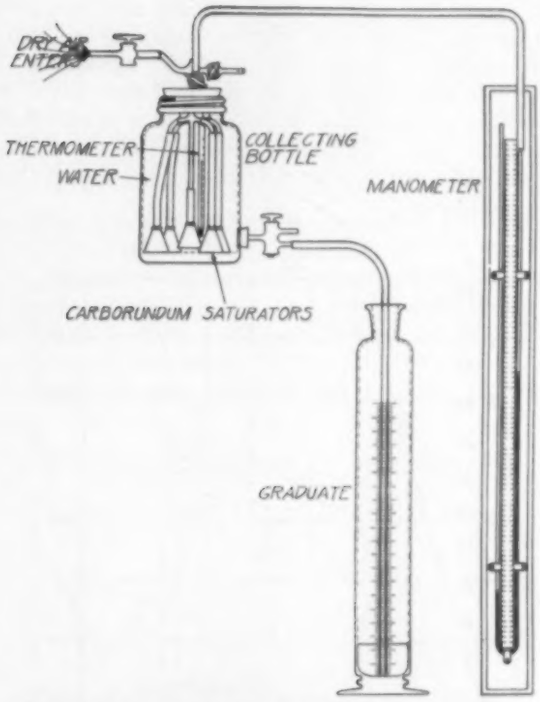

Fig. 5—Diagram of collecting bottle and manometer

Fig. 5a—Photograph of collecting bottle and manometer

In general, the tests were run in the following manner. Test room conditions were stabilized at the conditions desired. The subject entered the room sometime prior to the test—usually not less than 20 min. The conditions of the nasal cavity were believed to be normal. Tests were run at the three positions indicated in Fig. 3 both for inspired *I* and expired *E* air and last of all one test at position No. 4. In *all tests* fairly deep and deliberate breathing was done at a rate which avoided over-

ventilation. The subject was standing and was moderately active. Tests with shallow breathing will require more convenient temperature measuring apparatus. The air sample was taken only during the latter part of each inspiration or exhalation in order to get a proper sample. Apparatus was originally developed to take samples automatically, but manual operation of a valve was found to be satisfactory.

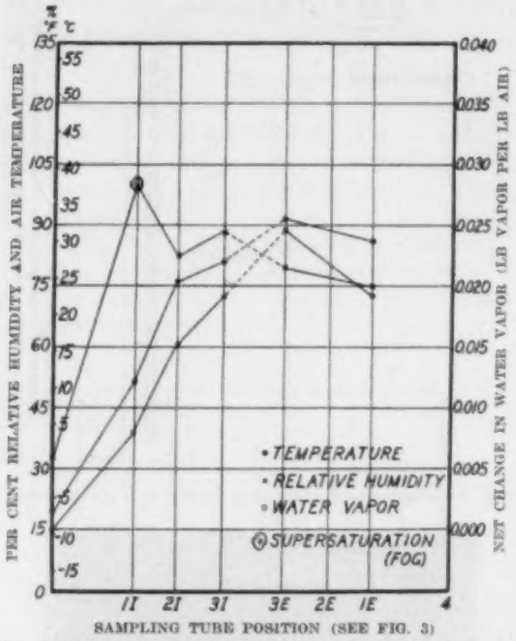
PER CENT RELATIVE HUMIDITY AND AIR TEMPERATURE
NET CHANGE IN WATER VAPOR (LB VAPOR PER LB AIR)
°F °C
• TEMPERATURE
• RELATIVE HUMIDITY
◦ WATER VAPOR
⊕ SUPERSATURATION (FOG)
1I 2I 3I 3E 2E 1E 4
SAMPLING TUBE POSITION (SEE FIG. 3)

Fig. 6—Changes in temperature, relative humidity, and water vapor versus sampling tube position

In passing, it should be mentioned that small samples of air cannot be safely conducted through rubber tubing without danger of a change in moisture content. Rubber was found from certain special tests to be too hygroscopic for accurate results. Some time was also spent in comparing the psychrometer against the absorption method of determining the moisture content of the air in the test room. It appears that the psychrometer indicates an amount of water vapor greater than the absorption method gives. However, if there is any error in psychrometer results it is less than physiological variations.

The air movement in the test room was rather vigorous. The current of room air reached the psychrometer first and then the subject. It is important for investigators to keep in mind that they constantly change the room air by involuntarily giving off heat, moisture, carbon dioxide, etc. Furthermore, it should be noted that some of the common methods of determining relative humidity will actually change the moisture content of the air used. This would be unimportant unless the total quantity of air used in the tests were small.

Figs. 6 to 8, inclusive, show general results selected from a number of test series. The increase of water vapor may be noted up to position *3I*. The dashed line indicates a slight increase in water vapor added by the lungs and interconnecting passageways. The nasal cavity apparently does the major bulk of the air moistening. Nose breathing through a normal nasal cavity allows very little water vapor to escape from the lungs.

From positions *3E* to 4 it will be noted that some water vapor appears to be recovered or absorbed in the nasal cavity during expiration. Fig. 9 shows the amount absorbed and also the per cent expressed in terms of the amount of water vapor added at position *3I*. At low temperatures the apparent recovery is probably condensation in part due to cooling but this cannot be true at high room temperatures.

Figs. 6 to 8 also show changes in air temperature. Cold air is heated and warm air is cooled. Since breathing is an intermittent process the anterior of the nasal fossa may be momentarily cooled below or heated above the average temperature of the surface. This is shown by the cooling or heating of the expired air. Surface conditions apparently change more rapidly than they can be counteracted during the same interval of time. When cold air is breathed there is a recovery of heat from the expired air as well as from the recovered (condensed) water vapor.

Relative humidity is defined as the ratio of the actual water vapor pressure (or density) to the saturated water vapor pressure (or density) corresponding to the temperature of the air and its associated vapor (dry-bulb temperature). It will be noted that air over pure water will become saturated when equilibrium is reached. The relative humidity will reach 100 per cent. However, air over any solution (i.e., body fluids) in equilibrium never can reach 100 per cent relative humidity. Saturation, in view of the definition given, can never occur due to the decreased water vapor pressure of the solution.

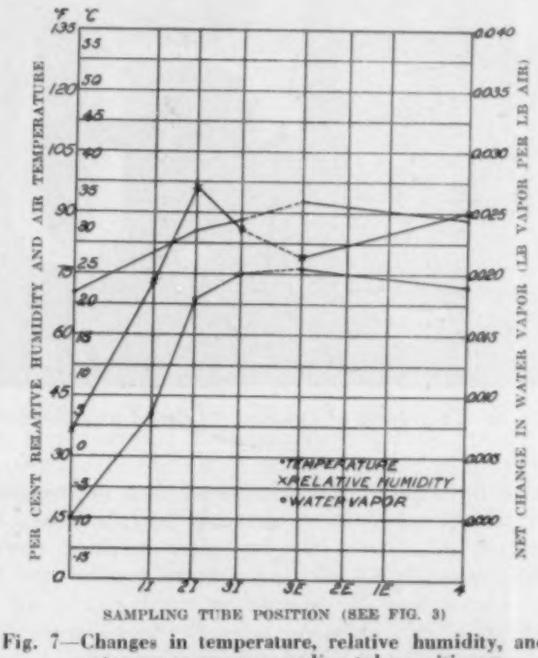
PER CENT RELATIVE HUMIDITY AND AIR TEMPERATURE
NET CHANGE IN WATER VAPOR (LB VAPOR PER LB AIR)
°F °C
• TEMPERATURE
× RELATIVE HUMIDITY
• WATER VAPOR
1I 2I 3I 3E 2E 1E 4
SAMPLING TUBE POSITION (SEE FIG. 3)

Fig. 7—Changes in temperature, relative humidity, and water vapor versus sampling tube position

The relative humidity curves in Figs. 6 to 8 show that saturated air does not come from the lungs. The curves seem erratic but they actually depend upon the water vapor and temperature readings which look consistent. It is possible for the relative humidity to decrease even when the water vapor increases because of the simultaneous rise in air temperature. Fig. 6 shows that cold air encountering warm, moist surfaces of the nasal cavity may produce a supersaturated or fog-like condition. It is possible in cold air to have a fog zone in some

part of the nasal cavity during inspiration and also during expiration.

Fig. 10 shows a more comprehensive picture of temperature changes. Neither at *3I* nor *3E* does the air temperature approach a standard value. If the surfaces in the nasal cavity were dry and uniform in temperature, the final temperature at *3I* would depend upon the initial room air temperature. This is in accord with the performance of air heating devices. The fact that the nasal surfaces are moist does make it possible for the air temperature to drop and then rise again. A thermometer with a wetted bulb will read lower than a dry-bulb thermometer unless the air is fully saturated.

The temperatures in the various parts of the nasal cavity depend upon the initial room temperature—breathing rates and air velocities being kept reasonably uniform. The invariable rise in temperature between *3I* and *3E* indicates that some heat is added by the lungs and interconnecting passageways. The temperatures at position 4 are the ones that should be used to compute the actual heat losses from the respiratory system. An expired air temperature of about 93 F (33.9 C) would be correct only if the inspired air temperature was about 70 F (21.1 C). The low-temperature curves suggest that very low-temperature air must enter the lungs at a low temperature and take considerable heat therefrom.

Fig. 11 shows temperatures when the room air is low in relative humidity (i.e., 13.4 per cent average). Fig. 12 shows the effect of different relative humidities, especially the *wet-bulb* effect. When air at about 70 F (21 C) is varied in relative humidity the variation of tempera-

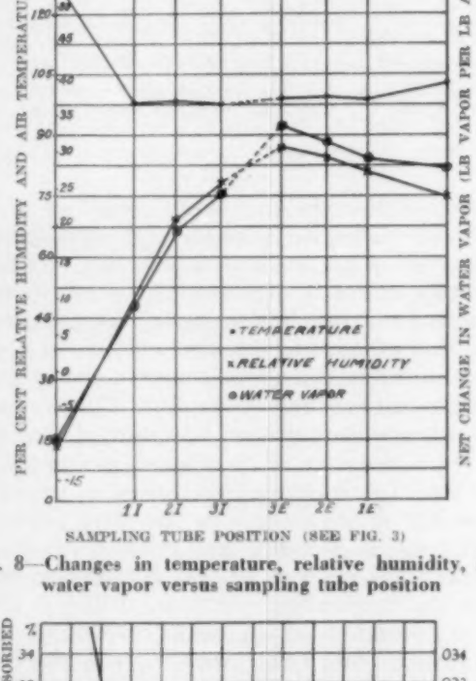
PER CENT RELATIVE HUMIDITY AND AIR TEMPERATURE
NET CHANGE IN WATER VAPOR (LB VAPOR PER LB AIR)
•TEMPERATURE
×RELATIVE HUMIDITY
○WATER VAPOR
1I 2I 3I 3E 2E 1E
SAMPLING TUBE POSITION (SEE FIG. 3)

Fig. 8—Changes in temperature, relative humidity, and water vapor versus sampling tube position

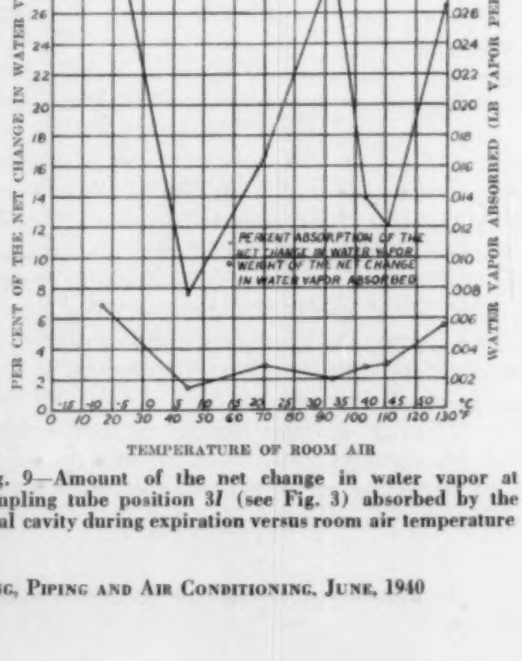
PER CENT OF THE NET CHANGE IN WATER VAPOR ABSORBED
WATER VAPOR ABSORBED (LB VAPOR PER LB AIR)
PERCENT ABSORPTION OF THE NET CHANGE IN WATER VAPOR = WEIGHT OF THE NET CHANGE IN WATER VAPOR ABSORBED
TEMPERATURE OF ROOM AIR

Fig. 9—Amount of the net change in water vapor at sampling tube position *3I* (see Fig. 3) absorbed by the nasal cavity during expiration versus room air temperature

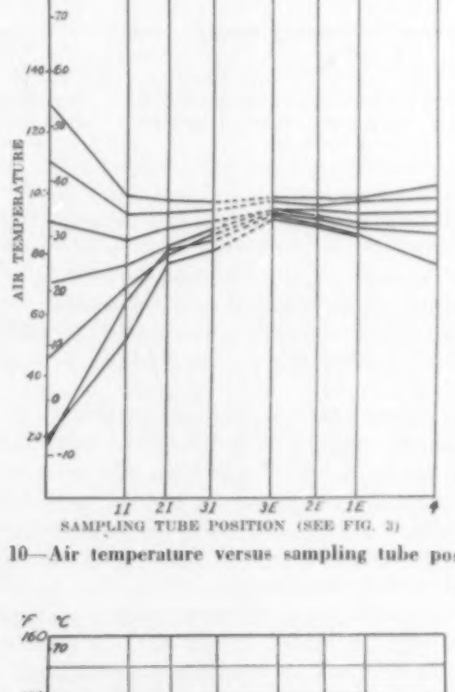

Fig. 10—Air temperature versus sampling tube position

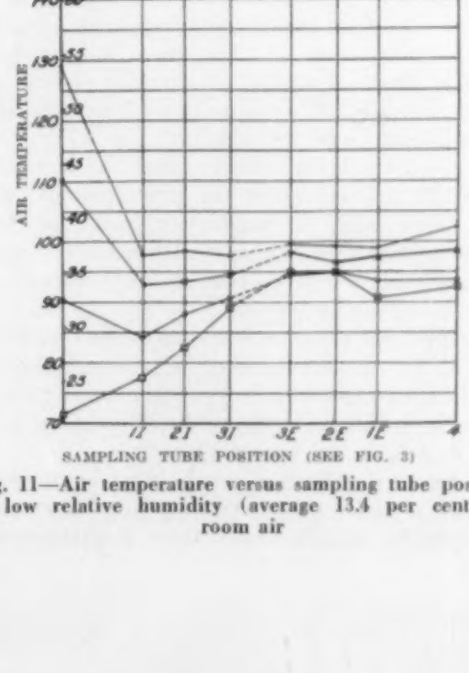

Fig. 11—Air temperature versus sampling tube position at low relative humidity (average 13.4 per cent) of room air

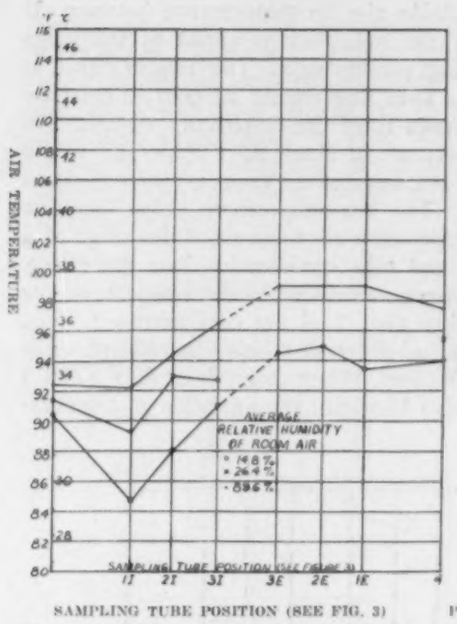

Fig. 12—Air temperature versus sampling tube position at different relative humidities of room air

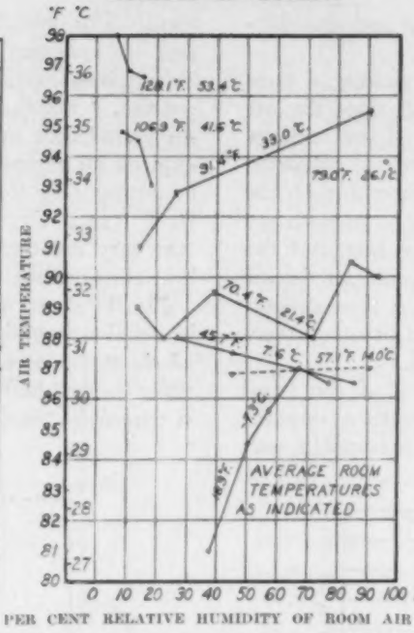

Fig. 13—Air temperature at sampling tube position 3*I* (see Fig. 3) versus relative humidity of room air

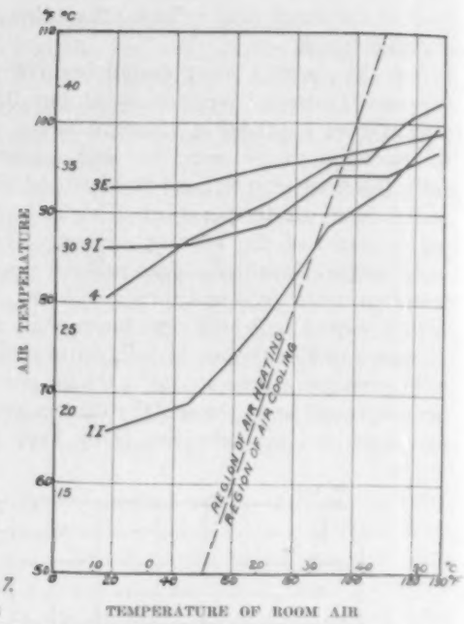

Fig. 14—Average air temperature at sampling tube positions shown versus temperature of room air

tures in the nasal cavity is not great. Fig. 13 shows that relative humidity has comparatively little effect upon temperatures at position 3*I*. The scale magnifies the differences that do exist though it roughly appears that room air of high relative humidity absorbs heat somewhat faster. This has been found true in tests of air-heating devices.

Taking average air temperatures regardless of relative humidities of room air, Fig. 14 shows temperatures in the nasal cavity at several positions. The area to the left of the dashed line represents air heating and to the right —air cooling. The manner in which the curves cross at high air temperatures reflects the cooling and reheating effects previously mentioned.

Figs. 15 to 17 show the water vapor in pounds per pound of dry air added at the various sampling tube positions at different room air temperatures and relative humidities. Fig. 15 shows most clearly how responsive the warm, moist surfaces in the nasal cavity are to different relative humidities. Fig. 18 shows the effect of various relative humidities at several average air temperatures for position 3*I*. The trend in every case is clear. Fig. 19 shows similar information plotted against the initial water-vapor pressure of the room air. Except for high-temperature, low-humidity air (Fig. 18) the 70.4 F (21.3 C) curve shows rather high evaporation rates. With one exception the maximum evaporating rate is about 0.025 lb vapor per pound of dry air. Whether or not this is a normal maximum cannot be known since the writer has been the only subject experimented upon thus far.

It appears that the most important effect of a sudden change of air conditions may be the equally sudden change in the evaporation rate. If the nasal cavity continues to be moist, as it should be, the change in evaporation is sudden and unavoidable.

This change in evaporation rate must be compensated for in time in order to maintain a normal mucous lining but how long it takes and what the consequences of even a short misadjustment may be are questions which remain to be answered. If moisture is evaporated from nasal mucosa at an accelerated rate, due to change of temperature and/or relative humidity, it follows that the characteristics of that mucosa must change in viscosity, surface tension, osmotic pressure, etc., unless a greater supply of water is added to this mucosa or else a greater quantity of mucosa itself is supplied. Unless compensation is instantaneous it must be conceded that at least the physical character of the mucosa is changed by its altered rate of water loss. This may be quite important.

From Fig. 18 it can be seen that going from 18.9 F (–7.3 C) air at 57.5 per cent relative humidity to a 70 F (21.1 C) room at 20 per cent relative humidity changes the evaporation rate from 0.0164 to 0.024 lb vapor per pound of dry air, an increase of 46 per cent. This situation could result when one goes indoors on a cold winter's day. While the physiological effect of a change in evaporation rate may be left to conjecture at the moment, it is true that no climatic or atmospheric changes can equal in speed and severity the change in the above example.

Figs. 20 to 22 show the absolute humidities rather than the net change in water vapor content per pound of air. In general, the greatest change takes place between positions 1*I* and 2*I*. The important fact is that the rate of evaporation per unit of surface is not uniform. A uniform lining of mucosa must require gradations in moisture or mucous supply at different parts of the nasal cavity. Otherwise, certain surfaces would be unduly dry and others unduly moist. The mucous lining would then be non-uniform. The cause of the differentiation in rate of supply from surfaces that are continuous and similar would be worth knowing.

Figs. 23 to 26 showing changes in relative humidity are of interest principally to show that the air never reaches saturation at the posterior of the nasal cavity (position 3*I*) nor does it ever appear to be saturated on

its return from the lungs (position 3*E*). The only way to supply saturated air is to have it virtually saturated at body temperature before breathing. (See Fig. 25.)

It may be repeated that the air samples were taken at each breath only during the latter part of the period. The air lying in the nasal cavity and passages should have been purged by this procedure before the sample was taken. The fact that higher relative humidities were found at other positions and even supersaturated conditions where they might reasonably occur should lend credibility to the observations even though at positions 3*I* and 3*E* they are contrary to general expectations. And again it should be repeated that whenever the water vapor in the air is in equilibrium with body fluids, the relative humidity can never be 100 per cent.

Figs. 27 and 28 show average enthalpy of air plus water vapor at various room temperatures for relative humidities below 50 per cent (Fig. 27) and above 50 per cent (Fig. 28).

Fig. 29 shows the enthalpy of the air at various temperatures and relative humidities of air for position 3*I*. As would be expected, the value changes very little at different relative humidities of the room air. Fig. 30 shows the enthalpy of evaporation and here the values are definitely responsive to variations in relative humidity.

Fig. 31 represents the sum of the values shown in Figs. 29 and 30. It shows the combined effect of the two characteristics previously noted. Fig. 32 gives the total enthalpy of the air plus water vapor at position No. 4. The curves for average air temperatures of 44.9 F (7.2 C) and 17.6 F (–8.0 C) were made from points which varied more than those values at the higher temperatures shown. It is clear that a determination of external body heat loss must take into account the proper loss due to respiration.

The results presented definitely show that nasal cavity air temperatures depend upon the initial temperature of the air with relative humidity having some modifying effect. There is always some rise in temperature between 3*I* and 3*E* even wnen the initial air temperature is above body temperature. Very low-temperature air undoubtedly throws a heavy air-heating burden on the lungs.

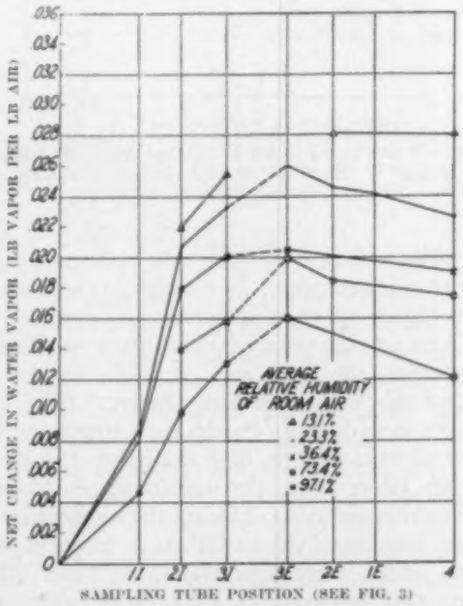
NET CHANGE IN WATER VAPOR (LB VAPOR PER LB AIR)
AVERAGE RELATIVE HUMIDITY OF ROOM AIR
▲ 13.1%
• 23.3%
• 36.4%
• 73.4%
• 97.1%
1I 2I 3I 3E 2E 1E 4
SAMPLING TUBE POSITION (SEE FIG. 3)

Fig. 15—Net change in water vapor at average room temperature of 70.5 F (21.4 C) versus sampling tube position

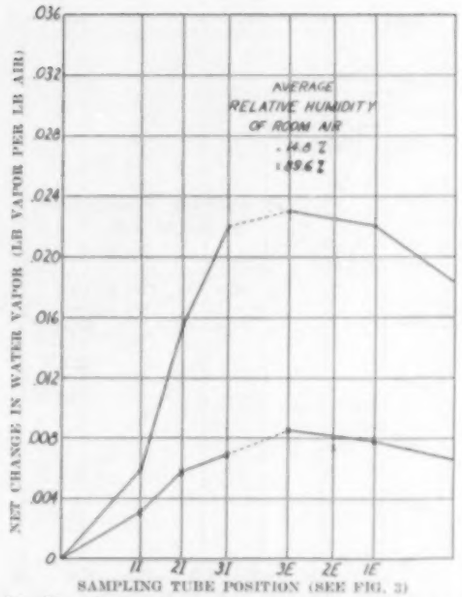
NET CHANGE IN WATER VAPOR (LB VAPOR PER LB AIR)
AVERAGE RELATIVE HUMIDITY OF ROOM AIR
• 44.8 %
• 89.6 %
1I 2I 3I 3E 2E 1E
SAMPLING TUBE POSITION (SEE FIG. 3)

Fig. 16—Net change in water vapor at average room temperature of 91.5 F (33.1 C) versus sampling tube position

It is clearly shown that an accommodation can be made to wide variations in moisture loss. Also it shows that the response in evaporation depends upon the initial water vapor pressure of the air even though the air temperature remains constant (Fig. 19). Actually both temperature and relative humidity determine the evaporation loss. Any horizontal line on Fig. 18 will indicate a variety of temperatures and relative humidities that will cause equal or unchanged evaporation rates. The comparatively small amount of water vapor taken from the lungs and the partial recovery of water vapor during expiration are both interesting results.

That the relative humidity of the air at 3*E* is never

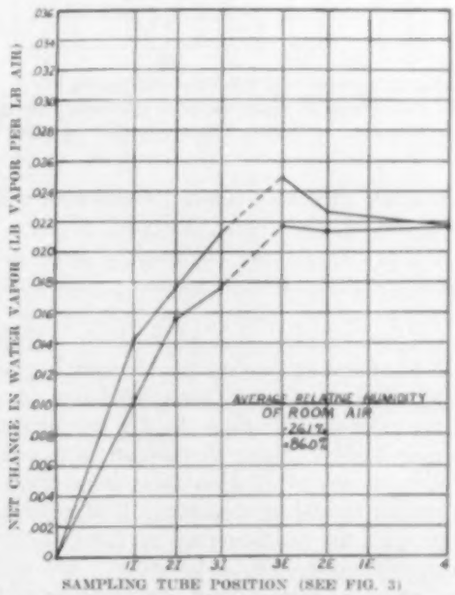
NET CHANGE IN WATER VAPOR (LB VAPOR PER LB AIR)
AVERAGE RELATIVE HUMIDITY OF ROOM AIR
• 26.1%
• 86.0%
1I 2I 3I 3E 2E 1E 4
SAMPLING TUBE POSITION (SEE FIG. 3)

Fig. 17—Net change in water vapor at average room temperature of 45.6 F (7.6 C) versus sampling tube position

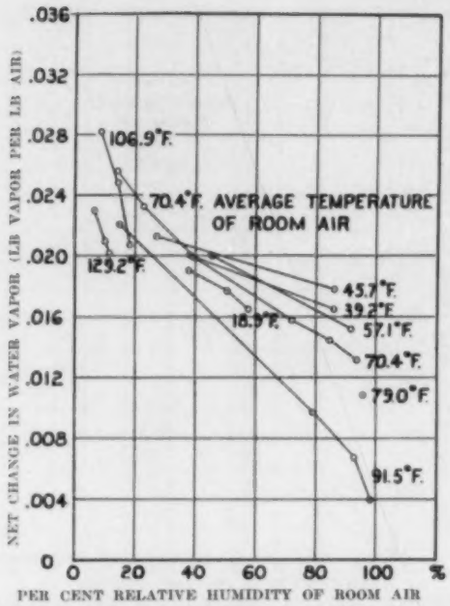

Fig. 18—Net change in water vapor at sampling tube position 3*I* versus relative humidity of room (see Fig. 3)

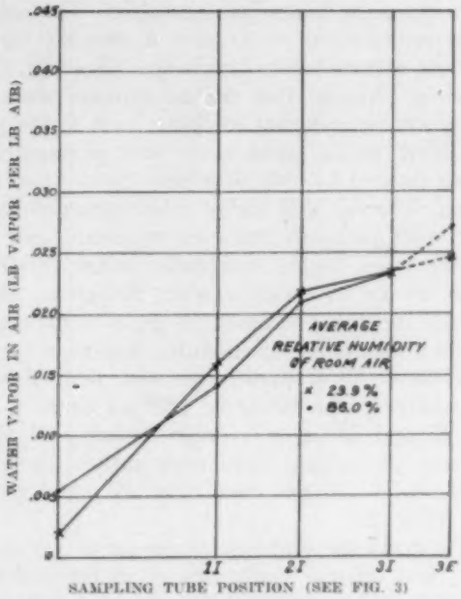
WATER VAPOR IN AIR (LB VAPOR PER LB AIR)
AVERAGE RELATIVE HUMIDITY OF ROOM AIR
× 23.9 %
• 86.0 %
1I 2I 3I 3E
SAMPLING TUBE POSITION (SEE FIG. 3)

Fig. 20—Water vapor in air at average room air temperature of 45.7 F (7.6 C) versus various sampling tube positions

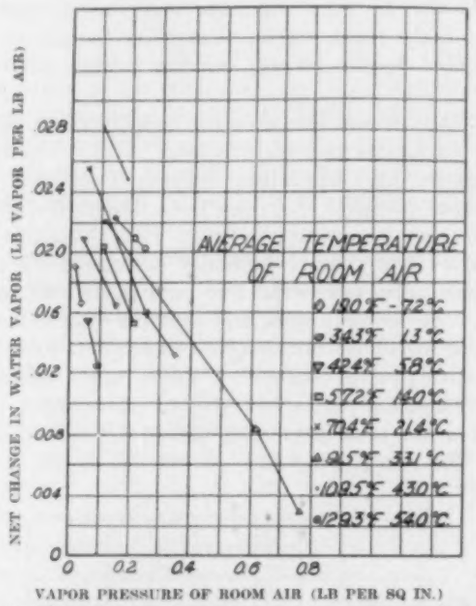
NET CHANGE IN WATER VAPOR (LB VAPOR PER LB AIR)
AVERAGE TEMPERATURE OF ROOM AIR
0 180°F - 72°C
● 343°F 173°C
▽ 424°F 218°C
□ 572°F 300°C
× 704°F 374°C
◇ 825°F 441°C
· 1095°F 590°C
○ 1293°F 700°C
0 02 04 06 08
VAPOR PRESSURE OF ROOM AIR (LB PER SQ IN.)

Fig. 19—Net change in water vapor at sampling tube position 3*I* (see Fig. 3) versus vapor pressure of room air

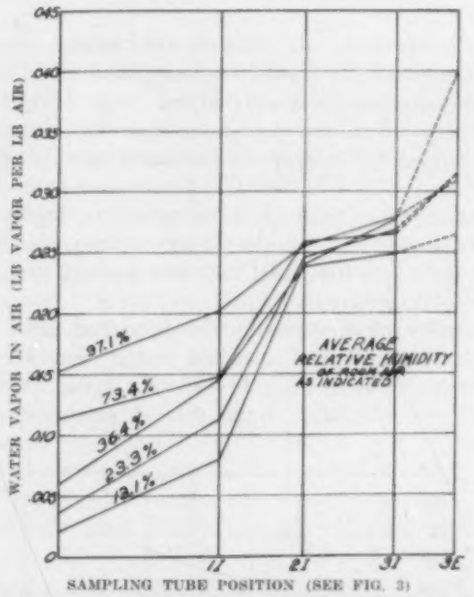

Fig. 21—Water vapor in air at average room air temperature of 70.5 F (21.4 C) versus various sampling tube positions

100 per cent and often well below 100 per cent will probably be viewed as surprising. Luciani, *Human Physiology* Vol. I, p. 397, states "The expired air is saturated or nearly so with the aqueous vapour exhaled along the respiratory passages." Also—"Its (expired air) temperature is approximately that of the body (35-36°C)." . . . It will be stated again that the air sample was taken only during the latter part of each inhalation or exhalation and that during this time the air temperatures remained quite steady. Since ventilation is a process of air control by means of dilution there is no good reason why expired air should be saturated. If alveolar air is in equilibrium with the fluid-covered surfaces of the lungs, further evaporation would be inhibited. The only way for water vapor to escape from the lungs would be by diffusion and mechanical mixing with respired air.

Final observations should include comments upon the swelling of the turbinates. In general this was associated with the higher rates of moisture loss from the nasal cavity. Also an occasional or momentary swelling might occur and pass during a test. It is the opinion of the writer that this may have been the local response to a momentary vaso-dilation due to nervousness or fatigue. If a general vaso-dilation or constriction has some corresponding effect upon the turbinates, an interesting speculation may be made. During the momentary condition above mentioned the variations in temperature from breath to breath were appreciable. Without such disturbances the temperatures were remarkably uniform.

At least one must concede that the nose is a very effective air conditioning device.

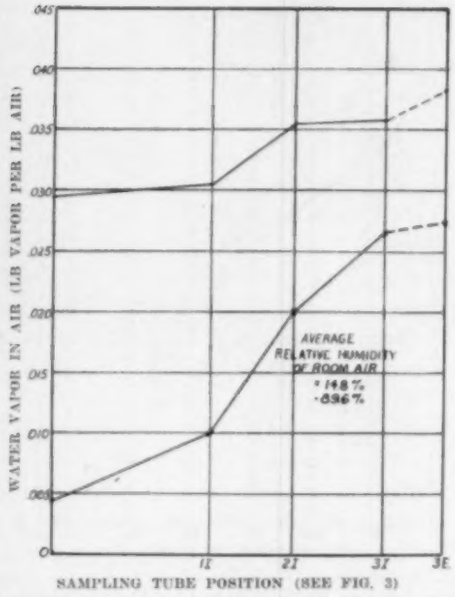

Fig. 22—Water vapor in air at average room air temperature of 91.5 F (33.1 C) versus various sampling tube positions

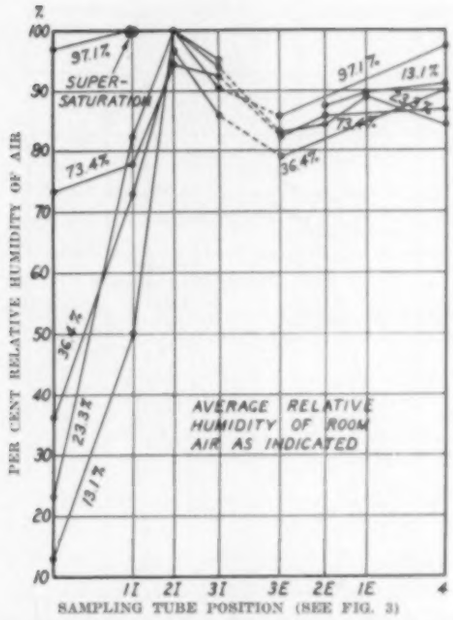

Fig. 24—Relative humidity of air versus sampling tube position at average room air temperature of 70.5 F (21.4 C)

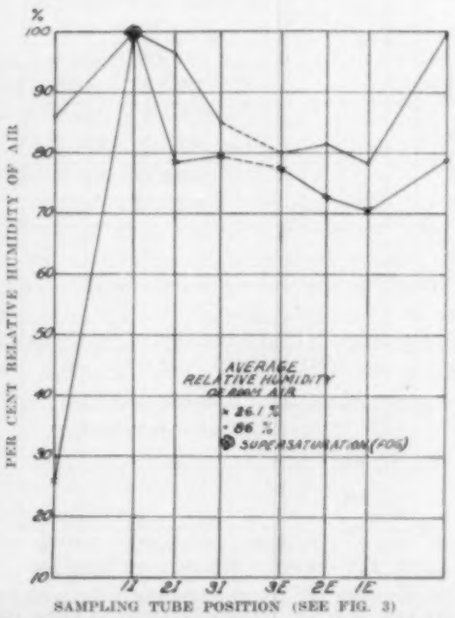
PER CENT RELATIVE HUMIDITY OF AIR
AVERAGE RELATIVE HUMIDITY OF ROOM AIR
SUPERSATURATION (FOG)
SAMPLING TUBE POSITION (SEE FIG. 3)

Fig. 23—Relative humidity of air versus sampling tube position at average room air temperature of 45.6 F (7.6 C)

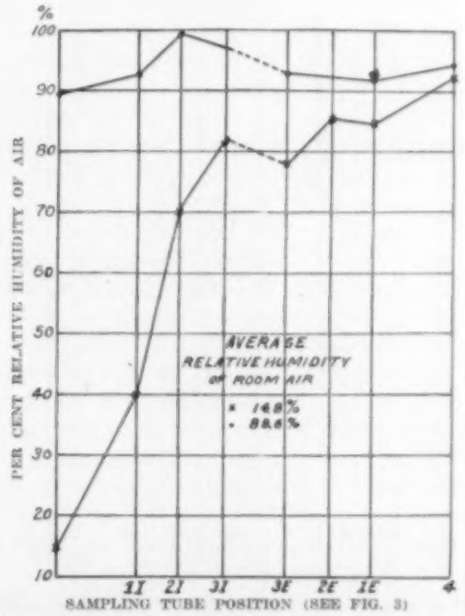

Fig. 25—Relative humidity of air versus sampling tube position at average room air temperature of 91.5 F (33.1 C)

Part II

The results given in Part I induce a desire to explain or speculate upon them. In the first place, the recovery of water vapor during expiration ought to be explainable on the ground of differences in water vapor pressure. It must be constantly realized that the nasal mucosa is being intermittently robbed of its water. An inhalation removes moisture with a speed which probably exceeds the ability of the body to counteract. If the water content of mucosa is temporarily lowered, the partial pressure of the water in the mucosa would also be lowered. The expired air does acquire some water vapor from the lungs and therefore its water vapor pressure will be increased. In such a case any tendency towards equilibrium would require a drop in the water vapor pressure of the expired air. This would involve the condensation of some of the water vapor in the air upon the mucous surface. Peters, in "Body Water" states "In theory, at least, then, the amounts of water lost by vaporization should be influenced by the osmotic pressure of tissue fluids at the exposed surfaces of the body." The possibility of condensation upon the tissue fluids must also be conceded in theory, at least. At any rate, the tests do show a recovery of water vapor during expiration

It does seem curious that temperatures at *3E* should exceed those at *3I* when the initial air temperatures are high (i.e., 130 F—54.4 C). While the temperature rise is slight it does suggest that small quantities of energy may be involved in the gaseous exchanges effected in

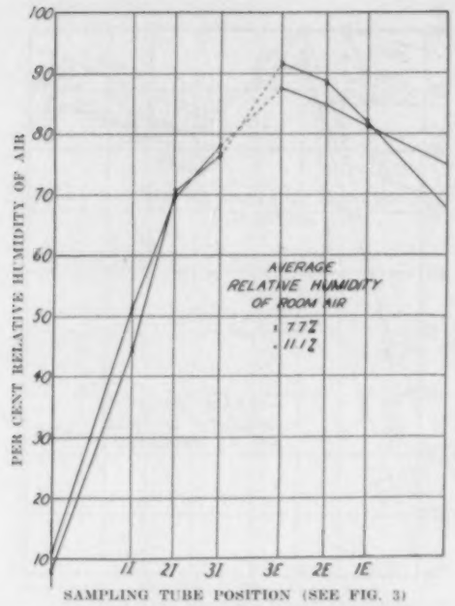
PER CENT RELATIVE HUMIDITY OF AIR
AVERAGE RELATIVE HUMIDITY OF ROOM AIR
77%
11%
1I 2I 3I 3E 2E 1E
SAMPLING TUBE POSITION (SEE FIG. 3)

Fig. 26—Relative humidity of air versus sampling tube position at average room air temperature of 129.3 F (54.0 C)

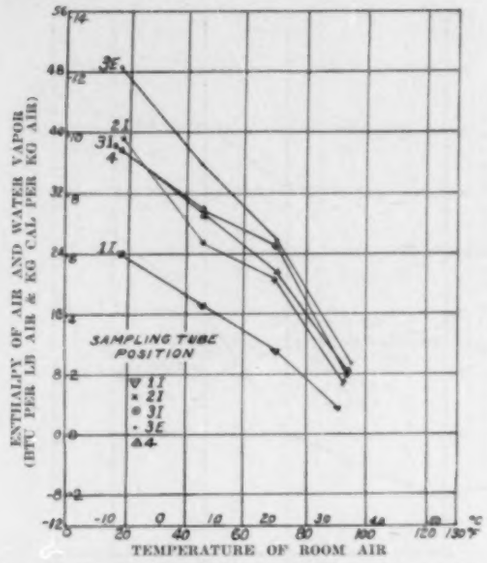

Fig. 28—Average total enthalpy of air and water vapor at sampling tube positions shown (see Fig. 3) versus temperature of room air

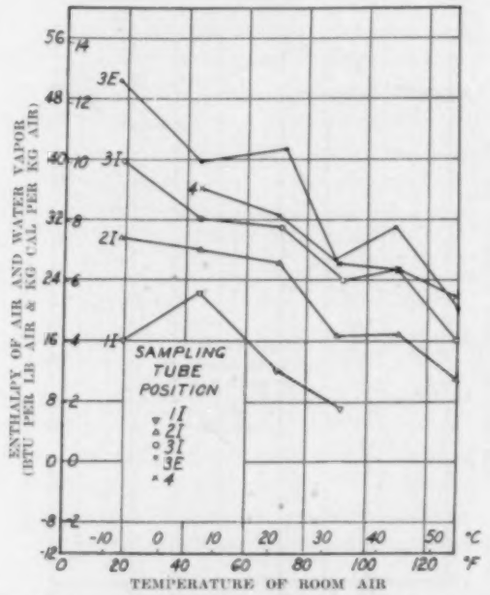

Fig. 27—Average total enthalpy of air and water vapor at sampling tube positions shown (see Fig. 3) versus temperature of room air

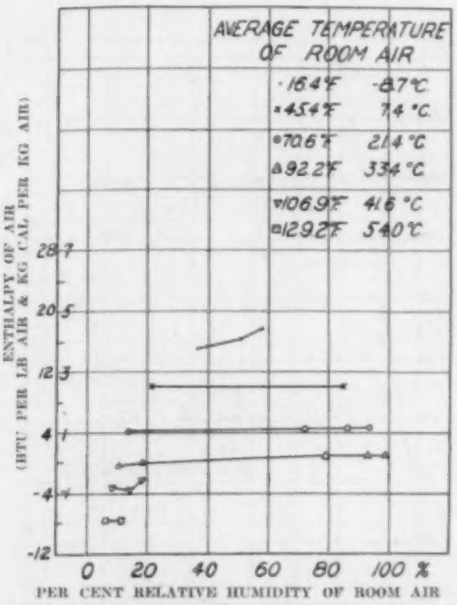
AVERAGE TEMPERATURE OF ROOM AIR
64°F -17.7°C
45.4°F 7.4°C
70.6°F 21.4°C
92.2°F 33.4°C
106.9°F 41.6°C
129.2°F 54.0°C
ENTHALPY OF AIR (BTU PER LB AIR & KG CAL PER KG AIR)
PER CENT RELATIVE HUMIDITY OF ROOM AIR

Fig. 29—Enthalpy of air at sampling tube position 3I (see Fig. 3) versus relative humidity of room air

the lungs and the physio-chemical changes associated therewith or that it is merely some of the heat given off by oxidation in live tissues.

The statement is commonly made to the effect that the normal nasal cavity is covered with a continuous film of mucosa, strong enough to be drawn slowly back to the throat by means of ciliated epithelium. Since mucosa must suffer a water depletion in its progress, the question arises whether the mucosa arrives at the back of the nasal cavity in an altered condition or not. It must be evident that a loss of moisture will affect viscosity, surface tension and osmotic pressure. If the loss of moisture is high it is conceivable that the mucosa would become too viscous to be moved by the cilia. This would destroy the cilia, produce discomfort and uncover tissues beneath the cilia to infection. If surface tension has any bearing upon the recognized germicidal characteristics of nasal mucosa then an excessive loss of water might deprive mucosa of its protective qualities. The change in osmotic pressure could induce a greater flow of liquid through membranes adjacent to the mucosa if osmotic interchange of fluids applies to the nasal cavity. This principle, if it is involved, would tend to correct or compensate for water loss.

It is reasonable to suppose that the nasal mucosa would retain certain normal characteristics all over the nasal cavity. In this case, however, it would be necessary in some manner to replenish the mucosa with the water that it is constantly losing. Merely adding mucosa along the path of motion would not maintain uniformity of viscosity, etc., though it would prevent absolute drying. However it is done, it is clear that supposedly normal mucous membranes can be preserved over wide differ-

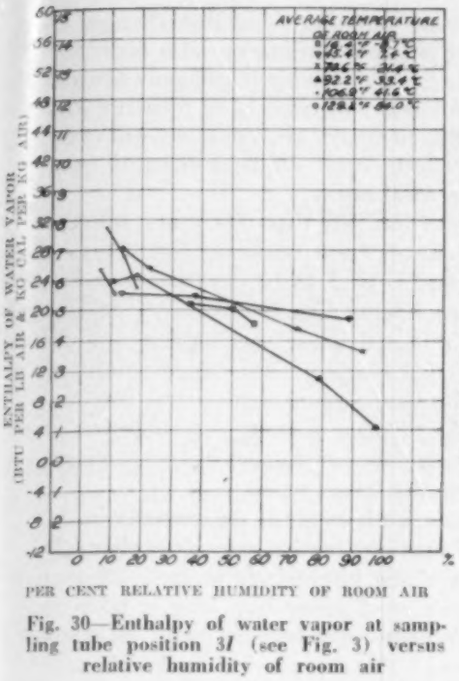
AVERAGE TEMPERATURE OF ROOM AIR
ENTHALPY OF WATER VAPOR (BTU PER LB AIR & KG CAL PER KG AIR)
PER CENT RELATIVE HUMIDITY OF ROOM AIR

Fig. 30—Enthalpy of water vapor at sampling tube position 3*I* (see Fig. 3) versus relative humidity of room air

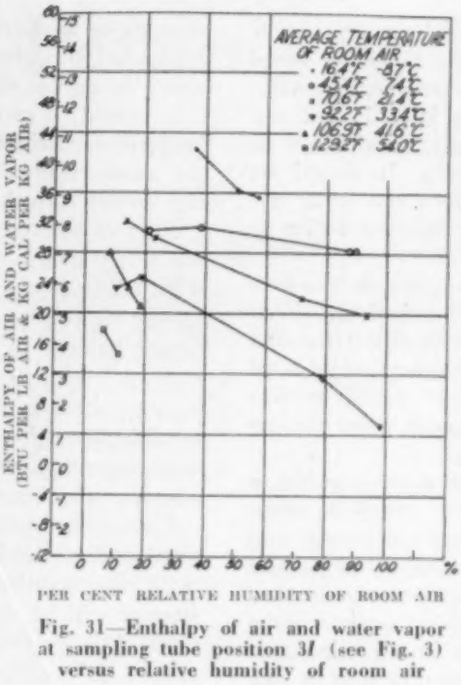
AVERAGE TEMPERATURE OF ROOM AIR
• 16.4°F -8.7°C
• 45.4°F 7.4°C
• 70.6°F 21.4°C
• 92.2°F 33.4°C
• 106.9°F 41.6°C
• 129.2°F 54.0°C
ENTHALPY OF AIR AND WATER VAPOR (BTU PER LB AIR & KG CAL PER KG AIR)
PER CENT RELATIVE HUMIDITY OF ROOM AIR

Fig. 31—Enthalpy of air and water vapor at sampling tube position 3*I* (see Fig. 3) versus relative humidity of room air

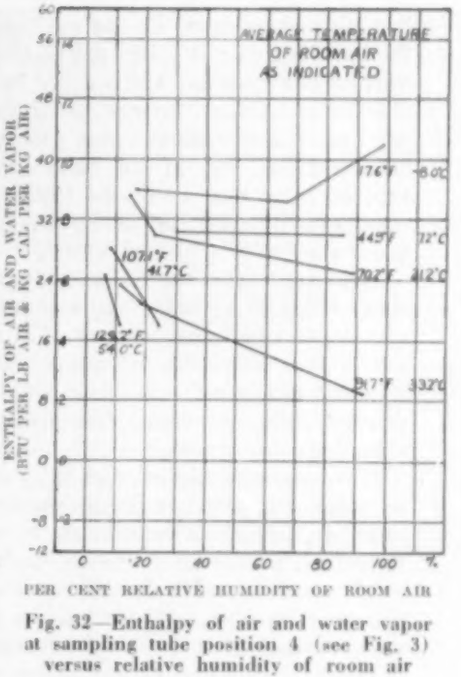
AVERAGE TEMPERATURE OF ROOM AIR AS INDICATED
176°F 80°C
107.1°F 41.7°C
70.2°F 21.2°C
129.2°F 54.0°C
92.7°F 33.7°C
ENTHALPY OF AIR AND WATER VAPOR (BTU PER LB AIR & KG CAL PER KG AIR)
PER CENT RELATIVE HUMIDITY OF ROOM AIR

Fig. 32—Enthalpy of air and water vapor at sampling tube position 4 (see Fig. 3) versus relative humidity of room air

ences in moisture loss which depend upon the temperature and relative humidity of the inspired air.

However, the most interesting consideration is the effect of a sudden change in air conditions. Figs. 18 and 19 show how the moisture loss would rise upon entering a dry, warm room from the cold outdoors. This suddenly altered rate of evaporation may change the viscosity, osmotic pressure and surface tension quickly with whatever physiological consequences may flow therefrom. Destruction of cilia or loss of germicidal protection in the presence of infectious organisms may result before the body accommodates itself to the new requirements. In such a case one could *catch* a cold upon entering a warm room where infection is present. It does not seem likely that the body could compensate for the accelerated water loss to avoid a brief but definite change in the physical characteristics of the nasal mucosa. It is proposed to ascertain the time required for this adjustment in future work.

It is probable that the excess of nasal mucosa experienced when passing from a warm, dry room to the cold outdoors is not due to increased production but rather to a lower rate of evaporation. The adjustment to this condition takes a number of minutes. The watering of the eyes might be caused in the same way since the surface of the eyes must be kept moist at all times.

If this sudden alteration in moisture loss from the nasal cavity is undesirable it follows that air conditioning ought to be governed to avoid drastic changes. Fig. 18 shows that indoor spaces should be humidified in cold weather. Horizontal lines in Fig. 18 would indicate what should be done. For moderately cold weather, relative humidities of indoor air at 70 F (21.1 C) ought to vary between 40 to 60 per cent. This is what everybody knows already. This effort merely provides a reason—a good one, it is hoped.

However, if one considers summer cooling of buildings one must conclude that the nature of the climate should decide the character of cooling. If the climate is hot and dry, the method of cooling should provide a dry indoor atmosphere. If warm and humid then rather moist indoor air would be better. These observations are based on the premise that drastic changes in moisture loss from the nasal cavity must be avoided where the change in environment is sudden.

If nasal mucosa serves mainly to protect the respiratory system against dust and infection it then appears that the moistening of the air is an unavoidable accompaniment. It is certain that the lungs function with tidal air below 100 per cent relative humidity and at no standard or fixed value. It is believed that the humidification of the inspired air may be more for protecting the throat from irritation than for any other reason. The consequences of mouth breathing, speaking and singing support the belief. It would be interesting to know if bronchitis may not be induced or at least aggravated by some failure of the mucous membrane to adequately humidify the inspired air.

In considering the elimination of carbon dioxide from the lungs Grandis (1900)[1] pointed out that water vapor is eliminated by expired air. He assumed that this water vapor originated in the lungs and pointed out that the blood must undergo a temporary increase in concentration during its passage through the lungs which raises the carbon dioxide tension and facilitates expulsion of CO_2 to the alveolar air. This increase in tension (pressure) was verified experimentally. What Grandis pointed out could not apply in the lungs but it could in the nasal cavity.

The blood in the nasal cavity must in some manner make up the moisture loss from the nasal mucosa. When this loss is large there must be an appreciable change in blood concentration and carbon dioxide pressure. Whether the swelling of the turbinates and the general discomfort induced is related to blood concentration, car-

[1]Luciani, Vol. I, p. 391.

bon dioxide pressure or the mechanical problems of a fluid exchange or is solely the result of a general vasodilation is a question which might be answered by suitable observations. It was noted in Part I that the swelling of the turbinates was generally associated with high moisture loss in the nasal cavity. It should be kept in mind that all of the tests were run while the conditions in the nasal cavity were assumed to be in equilibrium with the respired air.

With one exception, the maximum moisture loss was about 0.025 lb of water vapor per pound of air. This may be a limit characteristic of the person who was tested. It is reasonable to suppose that others might have different limits and that some might be definitely handicapped from a moisture-loss standpoint when the air conditions are severe.

If a vaso-constriction due to sudden chilling has a corresponding effect in the turbinates it would be interesting to discover if equilibrium in moisture loss is disturbed. A temporary deficiency in the supply of mucosa or of moisture supply thereto would induce a temporary change in the physical characteristics of the mucosa in the same manner that a sudden change in air conditions might do. The consequences, whatever they may be, can follow in the same way. If a change in the protective qualities of mucosa or the completeness of the mucous film may allow infection then one might "catch a cold" due to sudden chilling.

The act of sneezing suggests itself as an attempt perhaps by a sudden mechanical pressure in cells and glands to increase the quantity of mucosa quickly. If mucosa is a defensive agency the reason for sneezing is clear. Some mechanical effect (irritation) due to quick shrinking of the turbinates, breaking or spotty drying of the mucous film, changes in viscosity, etc., might be enough to induce sneezing. The quick increase in the supply of mucosa supports the opinon that, without sneezing, a longer period of time would be required to establish a new equilibrium due to the changed conditions.

In an article on influenza,[2] the following statement is of interest: "One catches influenza *only* through the nose, throat, windpipe or lungs. It is the mucous membrane lining these organs of respiration that provides the portal of entry." Could it not be the failure of the mucous membrane which permits infection?

In discussing an address by Dr. Dochez before the members of the International Congress of Microbiology in New York (1939) on the wide differences in the virulence of diseases affecting the upper respiratory tract, Mr. Gray says, ". . . we may imagine that certain variations in the environment of these invisible agents of disease have an effect on their potency. It is conceivable, for example, that slight changes in temperature, in blood alkalinity, in the contents of the cellular and intracellular fluids or in other bio-chemical factors affecting the virus, may be responsible for the strange shifts which produce new strains, and, it may be, new species of virus." The experiments reported in Part I do at least show that changes in temperature can occur and that changes in the moisture content of nasal mucosa can also occur for a time when the condition of the air is suddenly altered.

It should be mentioned that changes in moisture loss in the nasal cavity due to altered air conditions will exert the same relative effects upon fluids discharged from the sinuses into the nasal cavity.

It is of interest to mention that 300 years ago the use of a *tempering chamber* was recommended. Persons were advised to spend from 5 to 10 min in a chamber having air conditions intermediate in character. An unheated hallway in a heated house was suggested as an example of a *tempering chamber*. This recommendation is not suited to the tempo of modern times, however sensible it might be. Today persons are subjected to what amounts to many different climates in a most abrupt manner. Acclimatization takes time.

Future tests will be made to see if the response in the nasal cavity to different evaporation rates depends solely upon the condition of the inspired air or not. Also an attempt will be made to discover how long it takes to establish a new equilibrium associated with suddenly altered air conditions. Tests employing shallow breathing, the effect of nasal preparations, smoking, etc., suggest themselves. Also tests on persons suffering from apparently upper respiratory or even throat ailments might be deemed of interest. The primary object was to discover or establish more definitely the importance of relative humidity in the field of air conditioning. While the test results were associated rightly or wrongly with certain physiological responses it is at the same time realized that these responses might be produced by other means also. The testing of air conditioning devices is an engineering job. The tests herein were strictly performance tests of an air conditioning device (viz., the nose). The speculations are perhaps in the field ". . . where angels fear to tread."

In conclusion, no one today denies the importance of maintaining a complete and normal mucous lining in the respiratory tract. Anything that, even for a short time, can change the normal qualities of mucosa or the uniformity of its distribution must merit considerable study.

Acknowledgment

The experimental work involved in this paper was conducted in the Laboratory of Applied Physiology, Yale University. Through the courtesy of Dr. Howard W. Haggard a special room and other facilities were made available. A five-horsepower air conditioning unit was loaned by the York Ice Machinery Corp., York, Pa., for conditioning the special room. Drs. F. N. Sperry and N. Canfield, Yale School of Medicine, respectively approved the sampling tube used in the tests and examined the nasal cavity of the subject to verify that no harm should result from the use of said tube. Mason F. Smith, research assistant in mechanical engineering, gave invaluable aid in the conduct of the tests.

[2]The Problem of Influenza, by George W. Gray. (*Harper's*, January, 1940.)

Dirt Patterns on Walls

By R. A. Nielsen,* East Pittsburgh, Pa.

Introduction

AT THE end of the heating season in the spring the majority of homes are not uniformly dirty, but the walls often show a mottled or striated appearance, as illustrated by Figs. 1, 2, and 3. These furnish a picture of the structure behind the wall, similar to an x-ray, silhouettes of studding, laths, nails, etc., that form the wall and ceiling structure behind the paint, wallpaper, and plaster, which become more prominent as the heating season progresses. It is the purpose of this article to discuss the processes that may be responsible for the production of the wall patterns and possible methods that may be used to minimize them.

Diffusion and Convection

If a quantity of dirt is suspended in the air, it will be observed that the larger particles settle out quickly while the smaller ones, which in still air would settle out if given sufficient time, are prevented from settling by turbulence and convection currents. Together with these, there are very small particles in the air which would not settle out by gravity even in still air. In their action these particles begin to resemble gas molecules, the more so the smaller they are. Since fractional micron particles are but slightly larger than a mean free path for gas molecules in ordinary air, they no longer remain motionless in the air but bob about as they are hit at random by these molecules. Such particles are said to undergo Brownian movement; the smaller they are, the more the unevenness of gas molecule collisions affects them and the more violent and rapid their motion becomes. Such particles go in irregular paths that zigzag about. The important point is that the particles do not stay in one place but travel slowly and at random. Thus, even in still air, a particle near a wall will wander about until perhaps soon or perhaps after a long time it hits the wall. Since smaller particles move faster than the larger ones, a greater number of the small ones hit the wall in a unit time. Thus dirt deposited by diffusion will consist of more small than large particles.

The speed of Brownian diffusion will be illustrated by an example. If 0.1μ (micron) dirt particles are placed 0.1 mm from a wall, they will slowly spread out in all directions. From formulas[1] it is calculated that it will take, on the average, 25 seconds for half the particles to reach the wall; for 1 μ particles, again 0.1 mm from the wall, it will take ten times as long. If the particles were started twice as far away from the wall, they would, on the average, require four times as long to get there. For the range of temperatures found in rooms, the Brownian diffusion is independent of temperature. From this it is concluded that the rates of diffusion of the particles are very slow and are significant for dirt precipitation, only if the particles are very near the walls. Diffusion will thus tend to deposit dirt uniformly on the walls, preference being given to the smaller particles.

As mentioned previously, convection and turbulent air currents also cause suspended particles to migrate; by these means particles are stirred and carried about rather quickly (a few feet per minute). The air currents decrease in velocity in close proximity to a wall, and there their magnitude can only be estimated. Very close to a wall, the velocity along the wall as well as any velocity perpendicular to it is assumed to be zero. Particles are thus continually being brought close to the wall by convection. Should convection bring them into contact with the wall, it would be expected that they should, as in the case of diffusion, be deposited fairly uniformly over large areas, and should not deposit so as to form local dark and light areas of such spacings as are used between laths. Any patterns formed by convection should indicate lines of air flow, not structure behind the wall surface.

Convection tends to keep dust from settling out of the air and, in this way, helps to maintain a higher dust concentration in rooms; however, it seems that the principal action of air currents in regard to structure patterns on room walls is to maintain the concentration of dirt particles up to within a small distance of the wall. This dirt, brought by convection, is the reservoir from which the dirt that deposits on the wall is taken. The actual transportation of the dirt, between the place where the velocity of the air currents becomes negligible and the wall surface, can be performed by diffusion and thermal precipitation.

Thermal Precipitation

Years ago, it was noticed by Tyndall, Rayleigh, Aitken, Lodge, Clark,[2] and others that heat had an effect on dust; a cold rod suspended in dusty air got dirty, while a hot rod remained clean. If a warm rod is put into a box filled with smoke, and suitably illuminated, a thin smoke-free region will be formed close to the rod's surface and the air rising directly above the rod will be clean. The thickness of the clean area depends on the temperature gradient near the rod.[3] Utilizing this effect, thermal precipitators have been built and found to operate satisfactorily.[3,5] The instruments take various forms but essentially are a hot wire in a cold tube or a hot wire between parallel plates. The plates or tube must be sufficiently close to the wire (an eighth inch or less, depending on the temperature gradient) that the clean area surrounding the hot wire extends as far as the cold walls.

*Westinghouse Research Laboratories, Westinghouse Electric & Mfg. Co.

[1]The Kinetic Theory of Gases, by L. B. Loeb. (McGraw-Hill Book Co., 1934, p. 399.)

For presentation at the Semi-Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Washington, D. C., June, 1940.

[2]The work was reported in the literature between 1870 and 1885. References and partial abstracts of these works are given in references 2, 4 and 10.

[3]The Dust-Free Space Surrounding Hot Bodies, by H. H. Watson. (*Transactions Faraday Society*, Vol. 32, 1936, p. 1073.)

[4]Clouds and Smokes, by W. E. Gibbs. (Blakiston's Son & Co., Philadelphia, 1924, p. 62.)

[5]The Cleaning of Air and Gas by Thermal Repulsion, by S. C. Blacktin. (*Journal Society Chemical Industry*, Vol. 58, 1939, p. 334.)

Thermal Filters, by W. D. Bancroft. (*Journal Physical Chemistry*, Vol. 24, 1920, p. 435.)

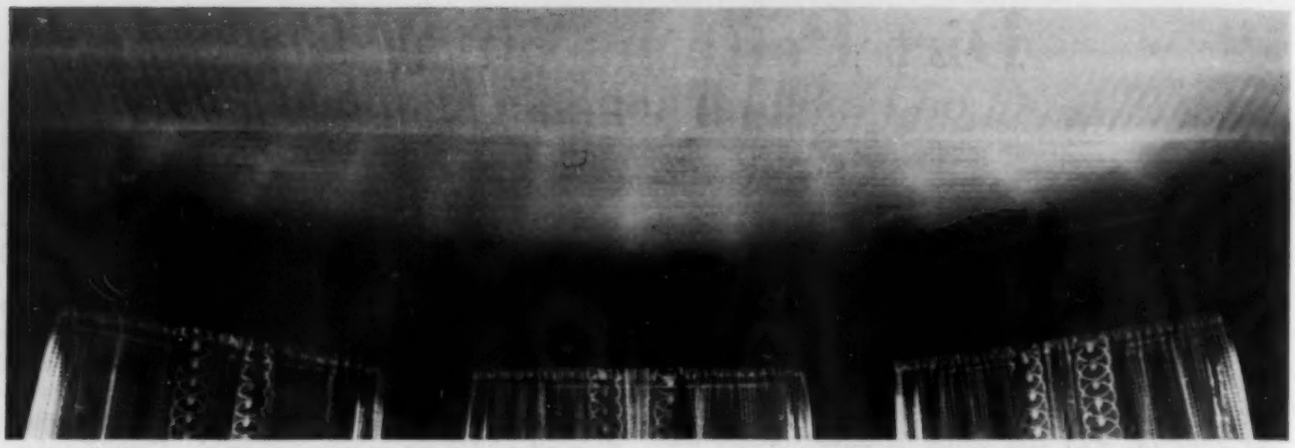

Fig. 1—Type of ceiling pattern characteristic of uninsulated ceilings; cleanest sections are beneath studding; dirtiest between laths. Wallpaper cleaner will completely remove pattern

Then, air passing between wire and walls will be completely cleaned.

The action of a temperature gradient on dirt particles suspended in air must be considered. As previously mentioned, small particles in still air bob about due to their being hit by random numbers of gas molecules with various speeds and directions. If there is a temperature gradient, heat energy is being transmitted by gas molecules from the hot to the cold region; the heat energy is transmitted by the molecules as kinetic energy of their motion. With such a transfer of energy comes necessarily a transfer of momentum. The particle, suspended in a region in which a temperature gradient exists, receives more momentum on its side toward the hot region than on the side facing the colder one; thus it moves toward the colder surface. Perhaps the effect could be more simply explained by saying that a dirt particle is hit harder by the faster moving molecules from the hot surface than it is by the slower molecules which hit it on the side facing the cold surface; thus it moves down the temperature gradient. Einstein[6] derived a formula for the force on small particles (less than 10^{-5} cm diameter) due to their being in a temperature gradient.

$$F = \frac{N}{2} KLS \frac{dT}{dx}$$

N = number of molecules per cubic centimeter.
K = Boltzmann constant.
L = mean free path of gas molecule
S = surface area of particle (proportional to r^2)
V = velocity of gas molecule
T = absolute temperature
$\frac{dT}{dx}$ = temperature gradient

The velocity of the dirt particle is given as $\frac{1}{8} V \frac{L}{T} \frac{dT}{dx}$.

From the last formula it will be noticed that for these very small particles the velocity is independent of the particle size. For particles above 0.1 μ the force becomes proportional to the radius instead of to the radius squared.[7] However, since the velocity of migration of the particle follows Stokes' law (velocity is proportional to force divided by particle radius), the velocity of these larger particles is also approximately independent of their radius since the force is now proportional to the radius. Therefore, the velocity of drift of particles in a thermal gradient is about the same for all particles.

Measurements of temperature gradients in rooms were made using a No. 36 (B and S gage) copper-constantan thermocouple, a type K potentiometer, and a sensitive galvanometer. The junction was supported away from the wall by taping the wires to the wall 1 in. or so from the junction. At the wall, open or covered thermocouple junctions normally gave a steady potential; when away from the wall as much as 1 mm, fluctuations of readings due to air currents were often observed. From the data of Watson[8] it is found that for a 9 F temperature difference between hot and cold surfaces, the clean region extends from the hot surface 0.1 or 0.2 mm toward the cold one, the distance being determined by convection. From this it is estimated that, in rooms, convection probably acts to within a fraction of a millimeter of the wall but at smaller distances the thermal gradients either form a protective dust-free layer over the surface, if that surface is warmer than the surrounding air, or they aid in depositing dirt on the wall if the air is the warmer. From

[8]Loc. Cit. Note 2.

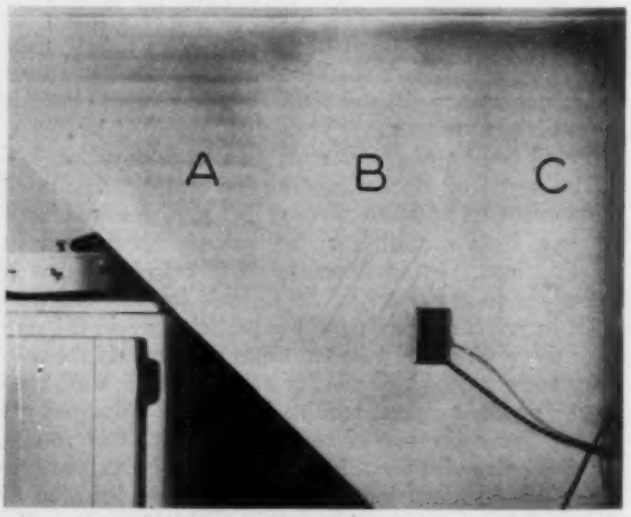

Fig. 2—A wall pattern

Section A shows the characteristic lath marks; better insulation results in a more uniform Section B. The heat conductivity of the studding between B and C, as evidenced by the vertical dark area behind which is the studding. Note at the top of the picture the clean line at the wall junctions

[6]Zur Theorie der Radiometerkrafte, by A. Einstein. (*Zeitschrift Physik*, Vol. 27, 1924, p. 1. Loc. Cit. Note 1, p. 374.)
[7]Loc. Cit. Note 1, p. 378.

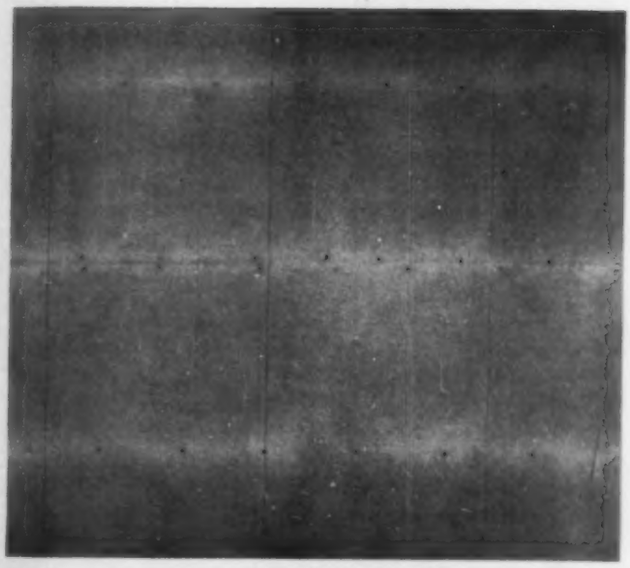

Fig. 3—Ceiling sections of an uninsulated plasterboard ceiling. *A (above)* is enameled; *B (below)* wallpaper-covered. Note the location of nails and studding

Fig. 4—Some painted pipes near a wall. Cold water pipe, originally similar to the others, has become very dirty

temperature measurements taken between the wall surface and a point a centimeter or two from the surface, curves were obtained from which the temperature gradients at the surface were estimated. (Measurements very close to the wall are generally meaningless since most anything used in making the measurements disturbs the conditions.) The measurements herein, however, indicate the magnitude of the gradients that may be expected.

Two sets of readings taken about 10 min apart at the same point on the inside of a plastered and painted brick and tile wall (of a 12 x 15 x 24 ft laboratory room) illustrate the variableness of conditions and the influence of convection. Fig. 5 shows a steep gradient with wide temperature fluctuations caused by a warm air supply register on the opposite wall near the ceiling; the points on the curve represent average values of the temperature. The other curve was obtained after the fan feeding that register was turned off; here the readings were steady, especially near the walls. It was found that wall gradients were not constant but depended on many factors, in particular, convection.

A series of measurements in the third floor apartment of a house, of which only the ceilings and walls of the third (top) floor apartment were glass wool insulated, illustrates the magnitude of the temperature gradients that may be expected. The house is of brick veneer construction with slate roof and is heated by hot water radiators. With an inside temperature of 75 F and an outside one of 30 F temperature gradients up to about 1 F per mm were found at the wall surface.

There are numerous interesting commonplace dirt patterns that any postulated mechanism of dirt deposition must explain. For example: before the third floor apartment was insulated with glass wool, the ceilings of the house became badly striated during the heating season and showed *light* regions below studding and under laths. Fig. 1 (though not of the same house) illustrates this type of pattern formation. Before the next heating season, the apartment was insulated as described, with the result that the patterns on the third floor walls were much different. The entire ceiling was quite clean and uniformly so, except for a series of *dark* rather diffused stripes below the studding. Without insulation, the greatest heat flow was through the plaster between laths (steep temperature gradient at the plaster surface); laths are poorer heat conductors than plaster, so the ceiling beneath the laths should appear lighter; similarly for the studding. After insulating, the low heat conductivity of the glass wool made the combined lath-plaster-glass wool section of the ceiling less conducting than the studding. Below the studding one might therefore expect the deposited dirt to be more dense than on other ceiling sections and there should be no evidence of lath marks. This was exactly what was observed. On the insulated ceiling, the surface temperature below studding was 1 F cooler than between them.

This particular house has a gable in every room on the third floor. The sides of some of the gables gradually acquired an appearance as illustrated in Fig. 2. (Temperature measurements were made on a north bedroom wall but the painted kitchen wall was photographed since the design of the bedroom wallpaper interfered with good photographic reproduction of the lath marks.) The markings are interpreted as being due to irregular and skipped spots in the insulation. In

Section *A* the temperature of the surface in front of the lath was from 0.05 to 1 F warmer than surfaces between laths. Similar temperature differences between the clean and dirty stripes of lath marks were found on the second floor walls which are of the brick veneer type construction but without glass wool insulation.

In the bedroom the uniform section (corresponding to *B* of Fig. 2) was 6 F warmer than the striated section *A*. The clean parts of the striations of *A* are dirtier than any part of section *B*. Curves showing the temperature as a function of the distance from the wall at points *A* and *B* are shown in Fig. 6; the temperature gradient at *A* is larger than at *B* and extends a greater

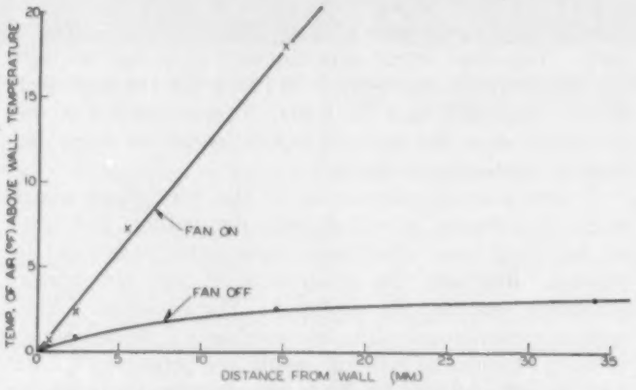

Fig. 5—Wall-air temperature differences for a laboratory room heated with hot air

distance from the wall. An increase in the convective currents in the room, due to colder inside window temperatures or hotter radiators, will increase the gradient at *A* more than at *B*, since it will effectively equalize the air temperatures near *A* and *B* at the same distance from the wall. Then, since *A* is colder with respect to the air temperature than is *B*, the temperature gradient there may be expected to be considerably higher than at *B*. No measurements were made during very cold weather, but it is common observation that the darkening of walls occurs much more rapidly at that time. This is ascribed to the increased heat loss and convection, both of which increase temperature gradients at the walls, as well as to the increased concentration of dirt in the air during that period.

In Fig. 3 are shown two pictures of the ceilings of a one-story un-insulated house with walls and ceilings of plasterboard. The ceiling shown in Fig. 3*A* is heavily enameled. The sections under the studding are lighter (cleaner) than neighboring ceiling parts. The presence of nails holding the plasterboard is indicated by prominent spots of much dirt deposition. On the left of Fig. 3*A* the joint in the plasterboard does not show, but its presence is indicated by the double row of nail marks. Near the right-hand edge there is a narrow but clean region at the junction of the ceiling and the inner wall. At the junction of walls the temperature gradients are necessarily reduced due to the geometry; also, since negligible air movement should exist there, one would expect very low thermal gradients and thus clean areas. Fig. 3*B* of the same house shows prominent perpendicular ridges due to lapping of the wallpaper; the less prominent ones are caused by lappings of underneath layers of the paper. As before, the studding and nails make known their locations, and this time the butting of two plasterboards shows as a dark line between a double row of nail marks. When the ceilings are cleaned, there remains no sign of any structure. The patterned dirt deposit is on the surface and can be easily removed. The photographs show a fairly uniformly darkened ceiling in the case of either wallpaper or enamel-covered plasterboard. The studding are poorer conductors of heat than the plasterboard; the areas below them are warmer and thus the studding marks are relatively clean areas. Through the plasterboard and into the studding go fairly heavy nails which conduct heat from the wall and ceiling surfaces to cool points deep in the studding, consequently the nail heads are cooler than the surrounding areas and the temperature gradients near them are greater than at neighboring points. Dirt is thus deposited there faster than at nearby points and the nail heads *showing* through the walls and ceiling can be seen. Actual temperature gradients at various nearby points need not differ greatly in order to form structure patterns since small changes in the amount of deposited dirt, if in a regular pattern, can be seen very easily, especially if viewed obliquely.

Fig. 4 is included because it shows an outstanding case of thermal precipitation. The five yellow painted pipes along the wall carry gas, vacuum, compressed air, hot and cold water. Obviously the right-hand pipe carries the cold water; a small section was wiped off so as to show that underneath the dirt coating it was painted the same as the other pipes. The pipe was cold but there were no marks to indicate that water had at any time condensed on the pipe.

Another example of thermal precipitation is the familiar patterned walls near radiators and warm air registers. Above the radiator the wall is generally dark; especially is it noticeable just at the top of the radiator where light and dark vertical patterns show the paths taken by air currents. The section of wall actually behind the radiator (excepting the top couple of inches) is really clean since it is heated by radiant energy to a temperature above that of the passing air. Convective and diffusive forces tend to deposit dirt on the wall but there the temperature gradients are large enough

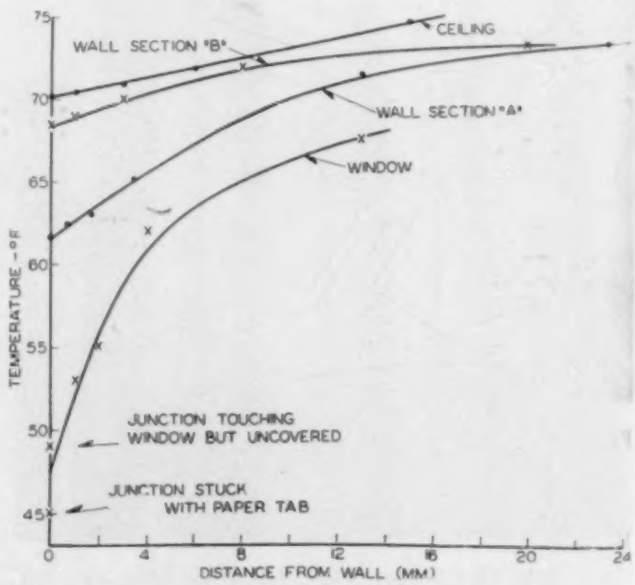

Fig. 6—Air temperatures near walls of a northern exposure room

to *repel* all dirt and the wall remains clean. Above the radiator the wall temperature becomes lower than the warm air temperature; convection and thermal gradients then act together with the result that the wall soon becomes coated with precipitated dirt. The warm air rising to the ceiling establishes a high temperature gradient there and the result is that the ceiling becomes dark. Above a supply register the case is similar to that of the radiator. The heated air is carried close to the wall and the temperature gradient is sufficient to cause precipitation of some of the dirt. If a hood or baffle is placed over the top of the radiator, it is found that the wall above the radiator is cleaner because the warm air has been deflected away from the wall and cooler air has replaced it. The old saying that "hot air is dirty" is true in that hot air certainly has the ability to establish temperature gradients which indicate on the walls that the air was dirty. Present day air supply grilles are often fastened snugly to the baseboard and painted over. However, after a year or so the paint at the joint between baseboard and grille may crack or be cracked due to shrinkage, warpage, or other causes and a slit between the grille face and the baseboard results. When this has occurred, a black smudge a half inch or so in length soon forms above the crack. In this case thermal precipitation is again to blame. The heated air slowly escapes through the crack and passes across part of the baseboard; the low velocity and high temperature of the air form a good thermal precipitator which deposits dirt on the cooler baseboard where it is not wanted.

The inside surfaces of windows become dirty in a rather short time, even if they are kept well above the dew-point. For a single-glass window with air temperatures of 75 F inside and 30 F outside, temperature gradients were found to be about 5 F per millimeter persisting for 3 mm before starting to level off (see Fig. 6). The actual surface gradient was undoubtedly steeper but even so this was at least five times the gradient at the room walls and more than ten times the gradient at the ceiling.

In air at 70 F the velocity of particles in a thermal gradient of 1 F per millimeter is calculated as 1.3 in. per hour. Since such a gradient was found in a room in moderate weather under minimum convection currents, let it be assumed that such a gradient persists for 24 hours a day for 6 months. In other words, the dirt in 3.2 cu ft of air would be deposited on 1 sq in. of wall during that time. This is a conservative estimate, since in very cold weather not only are the temperature gradients large, but also the dirt concentration is high. This means that a large percentage of the dirt deposition and pattern formation that takes place during the heating season occurs during the, often brief, cold periods. From blackness tests made during the winter months in large industrial cities where soft coal is used, it is known that 3 cu ft of air drawn through 1 sq in. of filter will darken it appreciably, depending, of course, on the day. The calculations, though very approximate, indicate at least that thermal gradients are of the right order of magnitude to account for the observed blackness.

Filtration, Electrostatic Charges, and Humidity

There are other means by which it may be possible to deposit dirt on walls. One of these is filtration. If air is drawn through a filter, the dirt is strained out and the filter darkens. The same is true for a wall. With a pressure difference across a wall there will be a flow of air through it, sometimes in, sometimes out. If the flow is outward, a deposit of dirt on the interior wall should be observed. The magnitude of the leakage[9] depends on the kind of plaster, the care used in plastering, the surface finish, wind direction, and velocity. The leakage through a section of wall will not be uniform, but will depend upon the structure of the wall since lath, plaster, and studding offer various resistances to air flow. Thus it seems possible to produce lath patterns on walls and ceilings due to difference in the resistance to air flow offered by lath and plaster. However, if this mechanism explains the presence of the cleaner regions under studding, and the dark spaces between laths, it fails to explain their reversal, namely, dark regions under studding and the elimination of lath marks when glass wool is used as insulation. Other observers[10] report that the surface finish, "waxing, painting, enameling, and ordinary wall-papering, does not appear to affect the peculiar affinity of dust for certain regions on the wall, particularly those regions over the spaces between lath". Bonnell and Burridge report that lath patterns could be obtained even when a layer of lead foil was used.[11] In the case of the ceilings shown on Fig. 3, one would expect no filtration through nail heads, but some through plasterboard. Thus the filtration theory predicts white spots below nail heads! It must therefore be concluded that, though it is possible to produce a wall structure pattern by filtering air through a wall, it is not the method by which most homes acquire lath marks and other dirt patterns on their walls.

It is also possible for electrical forces to produce precipitation of dirt in a room. However, it will be shown that, as in the case of convection, it is improbable. It has been found experimentally that clean air blown through ducts acquires no appreciable charge, but if it is dirty, charges of considerable magnitude can be obtained.[12] Also, it is reported that air blown over plaster becomes negatively electrified.[13] Voltages may also be present due to space charge such as is normally found in outside air. However, it seems hopeless to try to make electrical forces account for (1) the elimination of lath patterns and the reversal of studding marks after a ceiling was insulated with glass wool, (2) to explain light regions under studding, and, (3) to explain the formation of lath marks even when lead foil covers the surface.

It has been suggested that moisture is responsible for the pattern formation. The influence of moisture can be divided into two cases: (1) the walls are transmitting moisture into the room, (2) the room is transmitting moisture to the walls. If the walls are transmitting moisture to the room, the effect is a bombardment by water vapor molecules leaving the surface upon any particle near the surface. Its action is to maintain the

[9]Air Leakage Through Various Forms of Building Construction, by F. C. Houghten, Carl Gutberlet and C. A. Herbert. (ASHVE Transactions, Vol. 37, 1931, p. 177.)

[10]The Deposition of Dust on Walls, by W. H. Hooper. (*Physics*, Vol. 1, 1931, p. 61.)

[11]The Prevention of Pattern Staining of Plasters, by D. G. R. Bonnell and L. W. Burridge. (Department of Scientific and Industrial Research, England Building Research Bulletin, No. 10, February, 1931.)

[12]Generation of Static Electricity in Blower Systems, by A. H. Nuckolls. (Underwriters Laboratories Bulletin of Research No. 8, April, 1939.)

[13]Loc. Cit. Note 10.

surface cleaner than similar dry sections.[14,15] If the transmission of water vapor is in the reverse direction, one finds a force driving particles to the wall surface. Pattern formations are possible, therefore, if the various parts of the wall have different structures so as to permit the transmission of water or water vapor at different rates. Dampness of the surface may have some effect on the sticking of dirt which hits the wall; of this very little is known. However, experiments have shown that building a wall impervious to moisture or coating a wall surface with wax[16] does not prevent the formation of lath patterns. Arguments similar to those used against filtration and electrical forces will apply to humidity or moisture effects.

The effect of dampness and temperature gradients in keeping a surface clean is well illustrated in the case of the lungs. The action of constantly evaporating moisture and that of temperature gradients between the warm lung linings surrounding the cooler air help to keep dirt from depositing on lung tissues. As the hot rod when put into a smoky atmosphere surrounds itself with a dust-free space, so do the lungs establish a region about them through which gas molecules pass freely but dirt penetrates with difficulty.

Conclusion

Regardless of what method may be responsible for depositing dirt on the walls, that deposit can be minimized by reducing the dirt content of the air. This means air cleaning; the better the cleaning, the greater the reduction of the wall patterns. Air cleaners with high efficiencies are very useful for minimizing or even eliminating wall patterns as well as dirt deposits found near warm air supply registers, etc.

Though it is nice to have things clean, actually people will not object to a large amount of dirt on walls if it is deposited uniformly. A ceiling uniformly dirt-covered looks as before, except it has a grayer tinge. However, that same amount of dirt distributed non-uniformly, in lath patterns for example, is very noticeable, often objectionable. Since the amount of dirt deposited by thermal precipitation depends on the product of the dirt concentration by the temperature gradient, uniform heat insulation will reduce both general and patterned dirt precipitation on the walls by equalizing and minimizing temperature gradients.

Of the various methods by which it is possible to produce striated dirt deposits on walls, it appears that thermal gradients are responsible for the majority of those that are formed in homes during the heating season. The principal action of convection in pattern formation appears to be in increasing the magnitude of the temperature gradients and in maintaining high dirt concentrations in the air by decreasing gravitational settling out.

[14]Loc. Cit. Note 3.
[15, 16]Loc. Cit. Note 10.

Oregon Installs New Officers

April 29, 1940. Pres. J. D. Kroeker called the meeting to order and reviewed the history of the Oregon Chapter, introducing the present officers and Board of Governors, and the chairmen of the various committees who functioned during the year.

Chairman J. E. Yates of the research committee reported to the chapter the progress of his committee.

President Kroeker then discussed presenting the Delta Chapter with a gavel made of myrtle wood.

B. W. Farnes presented President Kroeker with a gavel appropriately inscribed from Oregon Chapter members.

Prof. F. E. Giesecke, who addressed the Oregon Chapter group at the banquet meeting in conjunction with the Air Conditioning Conference, installed the newly elected president, T. E. Taylor. He in turn charged the other officers and Board of Governors, who were elected at the March meeting of the chapter.

There being no further business, the meeting was declared adjourned.

R. E. Hattis Moves to Larger Quarters

Robert E. Hattis, air conditioning consultant, and mechanical and electrical engineer, a member of the ASHVE, announced recently the removal of his offices from 820 N. Michigan Ave. to larger quarters at 332 S. La Salle St., Chicago, Ill.

Montreal Members Meet

April 15, 1940. The regular meeting of the Montreal Chapter was held at the MAAA with 28 members and guests in attendance. The meeting was called to order at 7:45 p. m. by Pres. C. W. Johnson.

George Ballantyne welcomed the visitors, after which the speaker of the evening, Prof. W. F. Wells, was introduced by President Johnson. The subject of Professor Wells' illustrated address was Disinfection of Air. Considerable discussion followed his talk and J. D. Ross then expressed the chapter's appreciation to Professor Wells.

The minutes of the previous meeting were read and accepted, after which the meeting was adjourned.

Dehumidification in Air Conditioning Discussed at Western Michigan

April 8, 1940. The April meeting of the Western Michigan Chapter was held in the Rowe Hotel, Grand Rapids, and dinner was served to 38 members and guests.

Pres. B. F. McLouth called the meeting to order, and the minutes of the March meeting were read and approved.

The report of the nominating committee was made as follows: *President*—T. D. Stafford; *Vice-President*—W. G. Schlichting; *Secretary*—F. C. Warren; *Treasurer*—H. J. Metzger; *Board of Governors*—B. F. McLouth, H. J. Young and C. H. Pesterfield.

President McLouth then introduced Walter Badger, consulting engineer, Dow Chemical Co., as the speaker of the evening. Mr. Badger spoke on dehumidification in air conditioning, which he delivered in an interesting manner, and was well received. Many of Mr. Badger's statements brought out interesting discussion.

According to C. H. Pesterfield, secretary, the meeting adjourned at 10:00 p. m.

March 11, 1940. The March meeting of the chapter was also held at the Rowe Hotel, Grand Rapids, and was called to order by President McLouth, with 51 members and guests in attendance. The minutes of the previous meeting were approved as read.

This meeting was planned in honor of C. H. Morton, treasurer of the chapter, but due to his illness the April meeting was scheduled as Charlie Morton night. S. W. Todd introduced a resolution, which was passed, to pay Mr. Morton the respects of the chapter in the form of flowers. Mr. Todd was delegated to execute the resolution.

President McLouth then introduced the speakers of the evening, all of whom reported on papers given at the Society's Annual Meeting in Cleveland. The speakers were S. H. Downs, C. H. Pesterfield, and B. F. McLouth, who reported on the joint meeting with the *NWAHACA*, H. D. Bratt, O. D. Marshall, Prof. L. G. Miller, and T. D. Stafford, who reported on the Chapter Delegates' meeting.

Applications of Gas to Air Conditioning

By George E. May* (*MEMBER*), New Orleans, La.

Introduction

THE early days of air conditioning saw cooling as a primary function. It was produced largely by electrically driven refrigeration machines. And even today, cooling with incidental dehumidifying is still generally done by means of refrigeration.

During the past few years, as a result of costly broad research, equipment has been developed for cooling and dehumidifying air by means of gas. Recent refinements in design have made possible year-round air conditioning from one system and one fuel.

There are available today year-round air conditioning plants operated by gas, reasonably priced, hermetically sealed, with excellent operating records and designed to meet the strictest building code regulations.

Purpose

This paper will briefly describe the various systems in which gas is used for air conditioning and point out some of the more interesting characteristics of each. These systems will be classified according to functions and described in groups.

Functional Applications

Before describing the various systems operated by gas, it might be well to classify them according to their functional application.

1. Heating and Humidifying
   - *A.* Gas Heating Systems
     - (1) Direct
     - (2) Indirect—Gravity and Forced Air Circulation
       - *a.* Steam
       - *b.* Hot water
       - *c.* Hot air
2. Dehumidifying and Heating
   - *A.* Gas Activation—adsorption
     - (1) Silica gel
     - (2) Activated alumina
     - (3) Lithium chloride
3. Cooling and Dehumidifying
   - *A.* Gas—Refrigeration
     - (1) Gas engine reciprocating compressor
     - (2) Gas-steam turbine-centrifugal compressor
     - (3) Gas-steam-jet refrigeration
     - (4) Gas-steam absorption refrigeration.

Description of Systems

The following descriptions and characteristic data will be given in order of the classification:

1. *Heating Systems*: Heating and humidifying have been grouped here, not because they are incidental to each other, but because they belong together since humidification is generally required with heating. The majority of engineers are quite familiar with modern heating equipment and the use of various fuels. Detailed description of gas operated heating systems is, therefore, omitted from this paper. However, attention is called to improvements that have been made in the art, and to the important fact that nearly all modern heating equipment is highly adaptable to year-round air conditioning service. Improvements in design include such items as:

1. Extended surface coils adapted to hot or cold water.
2. Hot water circulating pump.
3. Forced air circulation.
4. Use of filters.
5. Control over temperature and humidity.
6. Duct distribution.
7. High wall registers and floor returns.
8. Controlled adequate ventilation.
9. Acoustical treatment.

A well designed heating system including these features can easily be converted to a year-round plant at relatively little expense.

In the great majority of cases humidification is required along with heating. Best practice seems to lean toward use of fine mechanical atomizers which direct a mist across the trailing face of the heating coil. Even in the case of steam coils, this method is desirable as it relieves the makeup water problem on the steam generating equipment.

2. *Dehumidifiers*: Direct dehumidification may be differentiated from incidental dehumidification in that it is a primary function. It is done by a process called *adsorption*. Highly porous materials are used such as silica gel, or activated alumina, which have great capillary attraction for moisture. As air is passed through beds of either material, the moisture in the air is adsorbed by the pores of the adsorbent material. For every pound of moisture thus adsorbed, approximately 1,000 Btu of latent heat are converted into sensible heat, manifesting itself in an appreciable temperature rise of the dried air. In most cases, this air requires cooling to acceptable temperatures before using.

These materials may be reused by *activation*. A blast of air at approximately 400 F is forced over the used, saturated adsorbent material. Heat carried by the air evaporates the adsorbed moisture, and, upon being cooled, the material is ready for reuse. The equipment is so arranged that this may be done in a continuous cycle.

Other adsorption media are concentrated solutions of highly hygroscopic salts such as calcium chloride and lithium chloride. The latter is used in a system in which air to be dehumidified passes through a fine spray of strong solution of lithium chloride. The chemical affinity of the salt solution pulls the moisture out of the air and results in a heat balance as described previously. Reactivation in this case is effected by the application of heat to less concentrated solution, driving off the moisture adsorbed and returning the solution to its original

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Presented at the 46th Annual Meeting of the American Society of Heating and Ventilating Engineers, Cleveland, Ohio, January, 1940.

concentration. Upon cooling, the solution is ready for reuse.

The heat for activation in each case is supplied by gas which has been found efficient, and lends itself to simple control.

3. *Application:* The adsorption-activation cycle is a very direct and efficient method of dehumidification. It involves a simple system with few moving parts. It finds a definite place in industrial and commercial applications where humidity control is the important problem. It is also adaptable to the comfort fields, especially where cooling water is available at low temperatures and reasonable cost. There are applications in the deep south where additional refrigeration is required due to higher water temperature. The market in these areas is probably limited by the need of two systems with resulting larger investment cost.

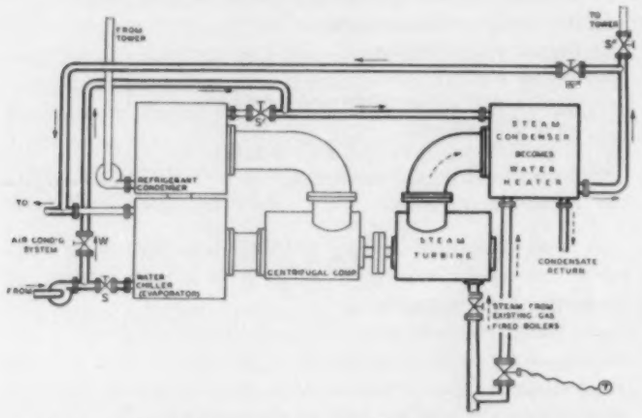


Fig. 1—Schematic diagram of conversion of gas-steam-centrifugal-compressor to provide winter functions

4. *Cooling and Dehumidifying Systems*: These two functions, when produced by refrigeration are incidental to each other. They are effected by means of washers or extended surface coils, with chilled water circulated from refrigeration units. The use of coils permits use of the counterflow principle and higher water temperatures. In many cases, direct expansion of refrigerant in extended surface coils is used.

The application of gas-refrigeration to these functions is accomplished generally by means of chilled water circulation through coils whose surfaces have been designed for both hot and cold water. Steam from a gas fired generator is used in the refrigeration unit to produce chilled water during the summer period. Steam from the same generator and the same fuel is used in a simple heat exchanger to produce hot water during the winter period. Either hot or cold water is circulated through the same system, so that one system and one fuel do the year-round air conditioning service.

The application of gas to refrigeration is found in four major types of equipment, and will be described in turn:

(*a*) *Gas engine driven reciprocating compressor:* This unit consists of a standard internal-combustion engine—equipped for burning natural gas, with automatic starter, clutch, etc., coupled on the same bed to a standard reciprocating compressor, employing a common acceptable refrigerant. Direct expansion of refrigerant is a feature of this system. It usually requires an independent heating plant to provide year-round functions.

Attempts have been made to provide heating by means of reverse refrigeration cycle and even use of waste heat recovery, etc. Economical operation is not possible in many cases and the reverse-cycle refrigeration principle is not in widespread use.

(*b*) *Gas-steam turbine driven centrifugal compressor:* Most engineers are familiar with the centrifugal compressor producing refrigeration in the form of chilled water, for circulation in washers or extended surface coils. Gas fired boilers generate steam which operates a turbine, directly coupled to a centrifugal compressor. The remainder of the cycle is identical with electric motor application. A simple and very interesting hookup is shown in Fig. 1 for converting this refrigeration unit to provide winter heating. The sketch shows the steam condenser used as a water heater. In order to change over from summer to winter functions, it is only necessary to close valves *S* and open valves *W* as can be seen, by following the diagram Fig. 1; the chilled water pump still circulates the water from the air stream coils in the air conditioning system. However, this water now bypasses the water chiller and is circulated through the condensing water coils in the steam condenser. The steam condenser now acts as a water heater and its operation is quite efficient.

Experience teaches that it is impractical to use the steam turbine as a reducing valve and allow it to roll over with the steam travel. The use of a small by-pass to the steam condenser, shown at right of diagram, with an independent valve is considered better practice. A modulating type of temperature valve can be used, actuated by a differential thermostat, arranged so that colder weather provides for warmer water. Air conditioning engineers appreciate the value of such an arrangement.

Engineers must recognize that this type of year-round conversion is possible only where air stream coils are used. Obviously, it is impractical where a washer is used unless the hot water for winter heating is circulated through a separate coil. Whether or not the latter plan should be used in any given case must be determined by an economic study.

This type of refrigeration is very attractive where air conditioning is being considered for buildings having high pressure boilers. Further, its compactness is an important feature in buildings where space is at a premium. This same steam generating equipment can be used for refrigeration requirements during summer months and the resulting fuel usage will establish an excellent annual load factor. Many utilities offer rates which reward good load factor, thus encouraging year-round use of boilers.

These units are built in sizes ranging from 50 to 900 tons capacity of mechanical refrigeration, and are simple to operate. The turbine-centrifugal combination has many good features, among which is its direct drive and full floating characteristics. Speed variation is no problem with turbine drive, and the power load falls off in proportion to the refrigeration load. The field records of such installations have been consistently good over a long period of time. In fact, the original centrifugal compressor was turbine driven and is still operating satisfactorily.

Operating records are available on one large gas-steam turbine centrifugal installation in a New Orleans office building. Separate metering and log records made it possible to analyze a full year operation, and it is presented in Table 1. The season over-all average gas use for 1939 was 27.4 cu ft per ton of refrigeration delivered to the washers. This figure takes into

Table 1—Analysis of Over-All Efficiency of Gas-Steam-Turbine-Refrigeration Part of Air Conditioning System

Period	*A* Chilled Water Pumped During Month Total M Gal	*B* Int. Avg. Water Temp. Diff. Dt.	*C* A x B x 8.3 12,000 Total Tons	*D* Gas Input Total MCF	*D/C* Monthly Gas/Ton
May 16-June 15	2,762,640	4.13°	131,200	3,167.3	24.20
June 16-July 16	3,066,080	4.21°	148,800	4,484.4	30.24
July 17-Aug. 15	3,313,180	4.33°	165,200	4,382.2	26.50
Aug. 16-Sept. 15	3,126,000	3.92°	144,000	3,854.4	26.70
Sept. 16-Oct. 14	2,307,420	3.86°	102,800	2,946.8	29.50

Average————27.4 = 18.3 lb steam/ton.

consideration all radiation and unaccounted for, boiler efficiency, steam for turbines and turbine auxiliaries, etc. Expressed in terms of water rate, there was a season average of 18.3 lb of steam per ton. With year-round use of gas, a rate was earned which made the operating costs of this system considerably less than it would have been for any other type of refrigeration system contemplated.

(*c*) *Gas-steam-jet refrigeration:* This is a very interesting and simple refrigeration cycle. The same water used for cooling and dehumidifying requirements is used as a refrigerant. As in the case just described, a chilled water pump circulates coil or washer water through the water chiller. In this case, the water returns, in the form of a spray, into an evacuated water chiller tank. A vacuum is produced and maintained with the aid of a steam ejector at the top of the chiller. The temperature of the water is a function of the vacuum maintained and depends, of course, upon adequate provision for evaporation of the water returning from the air conditioning units. The steam ejector discharges the steam and entrained flash vapor directly into a condenser where adequate cooling surface and cooling medium is provided to maintain a high vacuum. It is essential that the condensing medium, usually cooling tower water, be supplied at as low a temperature as possible. The condenser is connected to another small ejector, designed to remove air that comes over with the steam and flash vapor. The condensate from both condenser and condenser air evacuating ejector is returned to the boiler. A continuous water makeup to the chiller is required equal to the flash vapor removed.

The use of counter flow chilled water coils in air conditioning units is often desirable in place of washers since it permits a higher entering water temperature. This permits operation of the evaporator at a higher absolute pressure, which can be produced more efficiently.

The input per ton of refrigeration output varies widely with steam pressure at the ejector, and with the vacuum required. Forty-five degree water is accepted as a minimum for this type of system unless plenty of cool condensing water is available, as the pounds of steam per ton of refrigeration increase sharply with lower chilled water temperature.

There are a large number of steam jet installations throughout the world, varying in sizes from 10 to 600 tons capacity of mechanical refrigeration per unit. In a number of cases units have been multiplexed to give greater capacities. Operating experience has been very favorable, and indicates that the use of multiple units is good engineering practice.

(*d*) *Gas-steam absorption refrigeration:* This system has the distinction of employing one of the oldest principles of refrigeration, yet the system, as applied to air conditioning, is one of the newer developments. In fact, it is still being developed. Some equipment still in the laboratory, offering tremendous market possibilities, has not as yet been introduced.

This equipment uses gas as a fuel for producing low pressure steam. Fig. 2 may assist the reader in studying the interesting cycle. The steam furnishes heat for the distillation of a refrigerant from a solution of solvent and refrigerant, and this part of the cycle takes place in the heater. The refrigerant vapor, distilled off this strong solution, travels to a condenser where it is condensed to liquid refrigerant. The pure solvent or weak solution, having lost its absorbed refrigerant due to heating, drops to the bottom of the heater.

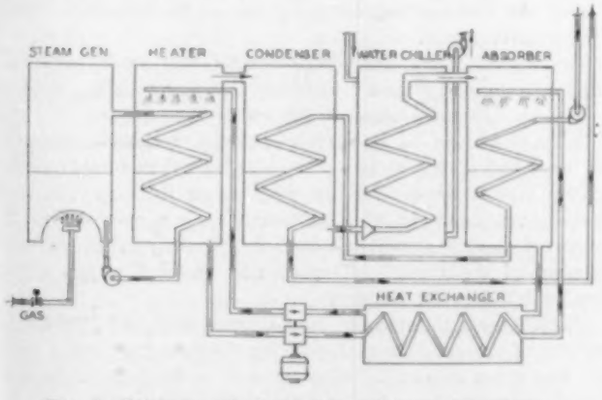


Fig. 2—Diagram of absorption refrigeration system

The liquid refrigerant in the condenser flows through a drying agent to a pressure reducing valve, where it is allowed to evaporate at a low pressure. The coils in which this evaporation takes place are immersed in water and the heat from the water furnishes the heat of vaporization as the refrigerant changes state. The refrigerant vapor, at low pressure, travels to the absorption chamber or unit where it comes in contact with a cool spray of weak solution or pure solvent having a high chemical affinity for the vapor. It absorbs the vapor so completely as to produce and maintain any desired low side pressure (corresponding to the refrigerant temperature required in the water chiller).

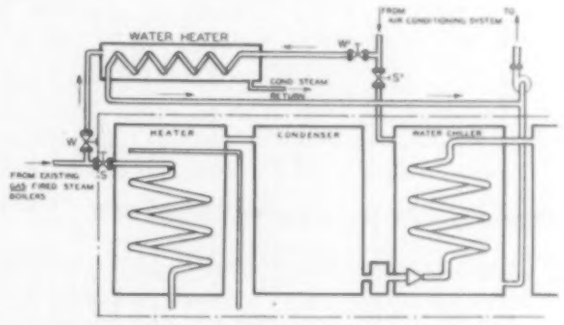


Fig. 3—Conversion of absorption system to provide winter heating

A small pump circulates the pure solvent from the bottom of the heater through a heat exchanger and to the absorber sprays. Another pump circulates the strong solution of solvent and refrigerant from the bottom of absorber through the same heat exchanger back to the heater where the refrigerant is again distilled off and starts the cycle over again.

As shown in Fig. 2, cooling water is required in both absorber and condenser, and the usual arrangement is that the water is circulated through the absorber and then the condenser in series.

The system uses methylene chloride as a refrigerant with a member of the prestone family, namely di-methyl ether of tetra-ethyl glycol as a solvent. Both are non-toxic, non-inflammable and non-corrosive, stable compounds. They may be handled in open buckets at atmospheric temperatures and pressures. When in use in the system the condensing pressure is approximately 0 lb and the evaporating pressure near 23 in. of mercury. Neither refrigerant nor solvent attack the metal used in the five simple shell and tube heat exchangers. With low operating pressures in hermetically sealed containers, there is little likelihood of trouble and loss of refrigerant or solvent.

These systems are available with gas operated steam generator, or provision for receiving steam from existing low pressure boilers. The steam pressure plays no important part, and may be supplied from 5 - 15 lb per square inch. They are quite efficient in their operation, requiring approximately 22 lb steam per ton of refrigeration output. Performance charts show a relatively little variation in pounds of steam per ton for different refrigerant and condensing water temperatures. The variation of capacity with refrigerant temperature is just about the same as for a standard reciprocating compressor operating under similar conditions.

Very recent developments in this equipment are in the direction of self contained and fully charged year-round

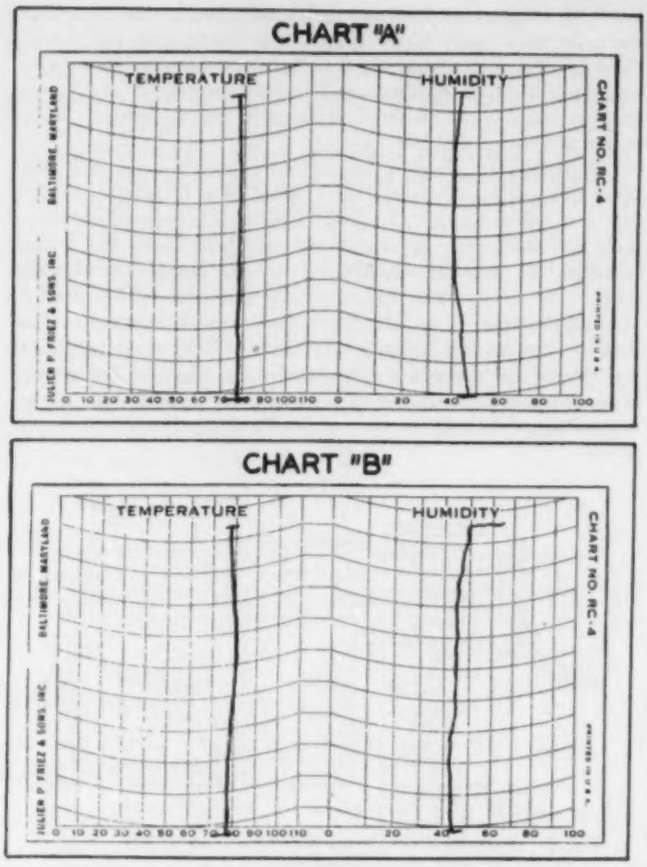


Fig. 4—Charts showing uniform temperature and humidity control in air conditioning systems

CHART "A"—TAKEN SEPT. 12, 1939

	Max.	Min.	6:30 a.m.	12:30 p.m.	6:30 p.m.
Dry-bulb	94	79	80	90	88
Wet-bulb	..	..	77	79	80
Per cent relative humidity	..	..	88	60	70

CHART "B"—TAKEN SEPT. 30, 1939

	Max.	Min.	6:30 a.m.	12:30 p.m.	6:30 p.m.
Dry-bulb	82	60	74	80	69
Wet-bulb	..	..	74	71	66
Per cent relative humidity	..	..	98	64	85

models. This is an important step which will attract wide interest.

Of interest, is the development of a simple and inexpensive heat exchanger for providing hot water during the winter season, using the same air conditioning unit and water circulating pump. The efficiency of this hook-up, and the case of change-over from cooling to heating operations, is worthy of mention. Fig. 3 shows part of a standard absorption refrigeration unit with a heat exchanger, or water heater, connected so that the change-over from summer to winter functions is effected merely by opening and closing a pair of valves.

As shown, the chilled water pump circulates water through the air conditioning system coils, in case of either cooling or heating. During winter months the water chiller is by-passed and the circulating water is directed to the water heater. This water is heated by steam from the same gas-steam generator. During the summer months, of course, the water heater is out of service and the absorption refrigeration system is in full operation.

As the old saying goes, "The best proof of a pudding is in its taste". The best proof that gas-refrigeration lends itself well to air conditioning is indicated in charts taken from actual installations showing control over temperature and humidity. Fig. 4 shows two such charts, taken from a recent installation in New Orleans.

The first chart was taken on a typical warm dry day, and the second on a cool humid day. The high internal heat load of the area being air conditioned required the system to operate on both days, and the charts show practically the same control over both sets of widely different outside conditions.

Summary

There is a rapid growth in the application of gas to air conditioning. Equipment has proved itself beyond any question of doubt to be substantial, simple to operate and efficient. Behind closed doors of research laboratories, newer and greater advances in the art are being tested for practical operation. All are working in the one direction—the same system, and the same fuel used for year-round air conditioning.

Pipe Corrosion Research

Several short lengths of pipe made from different materials and arranged in series are being installed in a number of large New York office buildings for the purpose of studying corrosion problems, according to A. R. Mumford, chairman of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS Research Technical Advisory Committee on Corrosion.

Test specimens will be located in the returns of systems supplied with steam from a central district heating source and from individual boiler plants. Action of the return condensate from the heating system on the corrosion of the several pipe materials is to be observed over a long period and will be reported by the committee at various times.

Ontario Holds Annual Meeting

May 6, 1940. The annual meeting of the Ontario Chapter was held at the Royal York Hotel with 41 members and guests present. Following dinner, Pres. H. D. Henion called upon the secretary to read the minutes, which were accepted as read. He then called for the report of the membership committee, which was presented by the chairman, H. G. Hill.

A wire was read from T. MacDonald expressing his good wishes to the Chapter for the coming year.

C. D. Waldon, chairman of the attendance committee, reported on the attendance throughout the year and urged that the chapter make a more concerted effort to increase the attendance.

E. R. Gauley, chairman of the entertainment committee, reported on the past year's activities, and outlined the Semi-Annual meeting plans to be held June 17-19 at Washington, D. C. Mr. Gauley will make arrangements for any of the Ontario members who wish to attend.

The report of the greeters committee was made by A. G. Ritchie, followed by the report of the past year's audit, submitted by W. C. Kelly, chairman of the auditor's committee.

In the absence of W. R. Blackhall, President Henion announced the awarding of $25.00 which the Chapter offers to the student at the University of Toronto who writes the best thesis on heating, ventilation or air conditioning. As a second gift, the chapter awarded a 1940 GUIDE; and finally, F. D. Ledgett, member of the Ontario Chapter, was awarded a year's free membership into the chapter.

H. H. Angus, chairman of the code committee, reported on the activity of the code committee during the past year, and pointed out that great interest is being taken in codes, both in the provincial governments and in the Dominion government.

Following Mr. Angus' report, there was a very interesting discussion, and the chapter as a body urged increased activity by the code committee, because of the great need for codes both locally and nationally.

D. O. Price, seconded by Mr. Ritchie, moved that the Board of Governors be empowered, if they saw fit, to appoint a committee to interview Mr. Nichols, Ottawa, who is director of the National Housing Act, with a view to investigating the possibility of getting the Ontario Chapter's Code for the Design and Installation of Steam and Hot Water Heating Systems for Residences having up to 50,000 cu ft of volume accepted by the National Housing Act immediately.

It was also moved by Mr. O'Neill, seconded by Mr. Shears, that the Board of Governors be empowered, if they saw fit, to allot $64.00 to this Committee for traveling expenses to see Mr. Nichols in Ottawa in order to get quick action, and the motion was carried.

C. Tasker reported on the activities of the *Affiliated Engineering and Allied Societies* in Ontario for the past year.

Following a report on the programs of the past year by Mr. Fitzsimons, President Henion called upon the members to make suggestions for improving the meetings, in view of increasing membership, and to make the meetings more interesting, and some 15 members offered their suggestions.

The following were unanimously elected to serve the Ontario Chapter for the coming year:

President—J. W. O'Neill
Vice-President—F. E. Ellis
Secretary-Treasurer—H. R. Roth
Board of Governors—C. Tasker, W. C. Kelly and D. O. Price

President O'Neill took the chair and a motion was then made and seconded that money be taken from the treasury to send cigarettes to members of the chapter now in active Army service overseas.

Announcement was made of a golf game to be held in the early summer, and Mr. Kelly asked the chapter to extend a vote of thanks to the secretary for his work during the past year.

It was moved and seconded that the Board of Governors be authorized to purchase a new lantern screen which would become the property of the Ontario Chapter to be used at meetings.

There was further discussion about the matter of getting the members as a whole to actively make suggestions for the programs of the meetings. It was suggested that if a blank questionnaire were sent with the meeting notices, the members would be more ready to make suggestions in writing, which would not need to be signed. Following this discussion the meeting was adjourned, according to H. R. Roth, secretary of the chapter.

President Giesecke Guest at Cincinnati

April 16, 1940. The monthly meeting of the Cincinnati Chapter was outstanding in that the chapter was honored by having the president of the Society, F. E. Giesecke, College Station, Tex., and the secretary, A. V. Hutchinson, New York, as the honored guests. There were 35 members and guests at dinner at the Netherland Plaza prior to the meeting.

Following the reading of the minutes of the previous meeting, which were approved as read, there were reports on the membership and finance committees. The legislative committee reported objections to the heating, ventilating and air conditioning requirements of the proposed building code of Cincinnati, which brought about a lengthy discussion. It was then moved and seconded that the secretary of the chapter write to the city manager and inform him that it was the consensus of opinion of the Cincinnati Chapter of the ASHVE that the heating, ventilating and air conditioning provisions of the revised building code of Cincinnati be given the same thought and consideration as the smoke abatement provisions of the code and request him to advise what action, if any, would be taken in this direction.

After a brief talk by Mr. Hutchinson on the affairs of the Society, Prof. F. E. Giesecke, professor emeritus at the Agricultural and Mechanical College of Texas, described recent research investigations in this country and in Europe on radiant heating where the heating elements or panels are embedded in the floors, walls and ceilings of the rooms. He further discussed the construction details and the reinforcing effect of pipe coils embedded in concrete construction and other interesting phenomena resulting from the application of concealed heating elements. In his talk, which he demonstrated by slides, he included actual facts and figures collected from studies of such installations in various parts of the country including an ultra-modern, heated and cooled office building in Racine, Wis. Following a rising vote of thanks to President Giesecke, the meeting was adjourned.

Research Committee to Investigate Sound Control in Air Conditioning

A. E. Stacey, Jr., chairman of the Committee on Research, announces that the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS will actively sponsor a cooperative research project at Rensselaer Polytechnic Institute, Troy, N. Y., to study sound control problems in air conditioning. Three factors of fundamental importance are essential in order to enable the engineer and contractor to accurately predict the noise levels in a conditioned space, according to J. S. Parkinson, Manville, N. J., chairman of the Technical Advisory Committee on Sound Control, which has been responsible for outlining the research investigations. First it is necessary to know the probable background noise levels which will be encountered in the conditioned spaces; second, it is necessary to know the amount of noise generated by the equipment and the air in the duct system; and, third, it is necessary to have a means of predicting sound attenuation through the duct system with and without the use of special sound absorbent materials.

The Rensselaer investigations are initially planned to develop a technique for measuring sound inside a duct and at the room outlet. Then the effect of duct size, thickness of metal, bends, elbows, turning vanes and splitters will be studied to determine the various attenuation losses which occur between the fan or conditioning apparatus and the room outlet.

Research Meetings at Washington

Sunday, June 16

10:00 a.m.—Research Executive Committee
2:00 p.m.—Committee on Air Conditioning Requirements of Glass
8:00 p.m.—Committee on Research

Monday, June 17

2:00 p.m.—Committee on Radiation and Comfort
4:00 p.m.—Committee on Air Distribution and Air Friction
5:30 p.m.—Guide Publication Committee

Tuesday, June 18

2:00 p.m.—Committee on Insulation
4:00 p.m.—Committee on Heat Transfer of Finned Tubes with Forced Air Circulation

Wednesday, June 19

2:00 p.m.—Committee on Sound Control
4:00 p.m.—Committee on Cooling Load in Summer Air Conditioning

Photo by F. A. Schutz

Welcome to Washington

Wardman Park Hotel - Washington, D. C.
June 17-19, 1940

IT IS time to go to Washington for the Society's Summer Meeting at the Wardman Park Hotel, June 17-19. There will be a fine gathering of members and their friends to enjoy the discussion of technical papers on such subjects as: heat gain through roofs; psychrometer problems; summer cooling requirements; fever therapy; radiator and convector performance; and air flow through registers.

Three technical sessions will be held—papers will be given at morning sessions and the afternoons have been reserved for sightseeing, golf, inspection trips, and other diversions.

All scheduled events are on Eastern Standard Time. S. L. Gregg and his Reception Committee will be on hand to greet early arrivals on June 16. Some of the ardent fishermen will leave the hotel at 8:30 a. m. for a day of fishing on Chesapeake Bay. Colonel Downs believes he has a clue to some big ones (supplied by the FBI no doubt). But come along and see for yourself—bait, tackle, and luncheon will be supplied.

Several committees have called meetings on the 16th and the Council will meet at 1:30 p. m. for an important session on Society business. Registration headquarters will be in the main lobby of the hotel and members should obtain badges, programs, advance copies of meeting papers, and all information about entertainment events.

A special room on the main lobby floor, near the registration desk, will be headquarters for the ladies. All events exclusively for ladies will start from this room. The official program will give further details.

Members who drive will find many interesting and historic spots en route to Washington, and the trip will not be complete without a visit to the New York World's Fair 1940.

The Committee on Arrangements for Washington Chapter has made special efforts to hold down the cost of every function so that members will find it possible to bring the family. All events are on an optional basis and charges for entertainment, golf and the banquet are moderate. A novelty entertainment will be held Monday night in the Continental Room. The Chapter members have written and staged an original production entitled, "Going With the Wind." Chairman Day has not revealed all of the plot but those who saw a preview are chuckling about the surprise that is in store for those who attend the Summer Meeting. Many of the songs and stories hit the bull's eye. The program provides a full hour of good, clean fun for the entire family. After the show there will be dancing and for those who desire a Buffet Supper, an elaborate Smorgasbord will be ready at 10:30 p. m.

On Tuesday evening the Semi-Annual Banquet and Dance will be held and arrangements announced by Chairman Spurney indicate that a fine Southern dinner will be served; there will be a short entertainment followed by dancing to the music of a well known radio orchestra. Tickets must be obtained in advance.

Plan to be in Washington for the meeting June 17-19. It is worthwhile to attend Society meetings.

Method of Choosing Location of, Financing and Conducting Meetings of the Society

Resolved: That inasmuch as the Annual and Semi-Annual Meetings of the Society come under the jurisdiction of the Council, the following rules governing the handling of such meetings be adopted by the Council and published in the JOURNAL of the Society at least twice during every year, preferably just prior to each meeting.

1—The Council will select the city in which the Annual or Semi-Annual Meeting is to be held, giving due consideration to the invitations received from Chapters or members as well as to the advisability of so distributing those meetings as to make them of the greatest advantage to the general membership, and to reduce as far as possible the expense of members attending.

2—That an appropriation be made to cover the entertainment or local expenses, incurred in connection with the meeting not exceeding $500.00, the regular meeting expense to be taken care of by the General Fund of the Society in the regular way.

3—That no registration fee or compulsory obligations of any nature be imposed on members or guests.

4—That the purchase of tickets for banquets or for any other form of entertainment that may be provided be entirely voluntary.

5—That the grouping of features and the sale of tickets for group features be discouraged.

6—That the raising of funds from manufacturers of heating apparatus be discouraged.

7—That the display of samples, or of literature, advertising the product of any manufacturer in any way, shape or form, be not permitted at the booths, registration desk, or in or about the meetings.

8—That the distribution of trade papers be entirely at the discretion of the committee in charge.

9—That the local Chapter or local members, be empowered to form a General Committee with such sub-committees as may be required to handle the details of transportation, hotel accommodations, entertainment, finance, etc., and that this General Committee be requested to confer frequently with the Council, through the Secretary of the Society, and to make frequent reports on progress in connection with the various matters being handled by them.

10—That the arrangements of elaborate and costly entertainment features be discouraged.

Adopted at Council Meeting, January 29, 1926.

PROGRAM

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Semi-Annual Meeting 1940

Sunday, June 16

8:30 a.m. Fishing Party on Chesapeake Bay ($2.50 per person)
10:00 a.m. Meeting of Research Executive Committee
1:30 p.m. Council Meeting
8:00 p.m. Meeting of Committee on Research

Monday, June 17

8:30 a.m. Registration—Main Lobby
10:00 a.m. TECHNICAL SESSION

Summer Cooling Load as Affected by Heat Gain Through Dry, Sprinkled and Water Covered Roofs, by F. C. Houghten, H. T. Olson and Carl Gutberlet

Air Conditioning Design of New Federal Office Buildings, by W. A. Brown

Dirt Patterns on Walls, by R. A. Nielsen

Discussion of Report on Nominating Committee changes

10:30 a.m. Ladies' Visit to White House (Bus leaves Hotel)
1:30 p.m. Golf Tournament—Congressional Country Club (Greens Fee $2.50)

Members desiring to participate in tournament must register with golf committee at registration desk prior to 11:30 a. m. First bus leaves hotel at 12:30.

2:00 p.m. Tour of Inspection—Bureau of Standards
2:00 p.m. Sightseeing Tour of Downtown Buildings.

Capitol, Pan American Union, Library of Congress, Supreme Court Building, Botanical Gardens, Washington Monument. Fare $1.30 per person (no charge for members' wives and children).

5:30 p.m. Guide Publication Committee Meeting
9:00 p.m. Informal Party and Show—Continental Room

An original playlet, "Going with the Wind," written and presented by members of the Washington, D. C. Chapter—Dancing after the Show and Buffet Supper (Smorgasbord) $1.40 per person.

Tuesday, June 18

9:30 a.m. Ladies' Motor Tour and Boat Ride

Lincoln Memorial, Lee Mansion, Arlington, Mount Vernon; Christ Church, Masonic Lodge in Alexandria; $2.50 per person (no charge for members' wives and children). Luncheon on boat 75c. Bus will meet boat for return to Wardman Park or trip to FBI demonstration at 2:30 p.m.

10:00 a.m. TECHNICAL SESSION

Study of Changes in Temperature and Water Vapor Content of Respired Air in the Nasal Cavity, by L. E. Seeley

Summer Cooling Requirements of 745 Clerks in an Office Building, by Dr. W. J. McConnell and M. Spiegelman.

Fever Therapy Locally Induced by Conditioned Air, by Dr. M. B. Ferderber, F. C. Houghten and Carl Gutberlet

The Problem of the Psychrometer—Part I. Historical Resumé, by H. B. Nottage and L. M. K. Boelter

1:30 p.m. Golf—Congressional Country Club (Greens fee $2.00 per person)
2:30 p.m. Tour through Federal Bureau of Investigation, U. S. Department of Justice (Round trip bus fare 30c per person)
2:30 p.m. Ladies' Card Party
4:00 p.m. Meeting of Nominating Committee
7:00 p.m. Semi-Annual Banquet and Dance

Wednesday, June 19

10:00 a.m. TECHNICAL SESSION

Methods of Rating the Noise from Air Conditioning Equipment, by John S. Parkinson

Air Flow Through Supply and Exhaust Openings in Buildings, by G. L. Tuve and D. K. Wright, Jr.

Effect of Room Dimensions on the Performance of Direct Radiators and Convectors, by A. P. Kratz, M. K. Fahnestock, E. L. Broderick and S. Sachs

10:30 a.m. Style Show for Ladies—Shopping Tour
1:30 p.m. Inspection trips to:

(a) David W. Taylor Model Basin at Carderock, Md.

Probably the most modern of naval test basins in the world, consisting of an administrative building, model shop, machine shop, and laboratory building where propellers are tested in water trails.

The building in which the testing basins are located is 1398 ft long, 112 ft wide, and 35 ft high. It is of the three-hinge arch roof type; the inside of the arch having 2 in. of insulation. The long basin is 21 ft wide, 10 ft deep, and 1347 ft long. The shallow basin is 51 ft wide, 10 ft deep, and 377 ft long. The deep basin is 51 ft wide, 21 ft deep and 1000 ft long. The tracks on which the carriages run, and which are located at each edge of the basins, are laid level within 1/1000 of an inch and in a straight line within 1/100 of an inch. The tracks are also being laid with the curvature of the earth.

(b) Central Heating Plant

The Central Heating Plant is located between C and D and 12th and 13th Streets S. W. It was completed along with the steam distribution system in January, 1934, at a cost of approximately $4,000,000. At the present time it furnishes steam to 76 buildings with the prospect of at least four additional large buildings in the near future.

Six large boilers are installed in the plant, each one capable of converting 215,000 lb of water to steam every hour at a pressure of 200 lb per sq in. On a single cold day in January, 1937, more than 15,000,000 lb of steam were converted using approximately 700 tons of coal; approximately two billion pounds of steam are produced yearly and require the burning of nearly 100,000 tons of coal.

The steam is distributed to the various government buildings through more than 15 miles of pipe lines laid in tunnels and conduits below the ground.

(c) Capitol Group of Buildings

Refrigeration Plant: The refrigeration plant is located adjacent to the Capitol Power Plant. There are installed in the refrigeration plant six reciprocating refrigeration machines having a total tonnage of 5000 tons. Water for condensing is obtained from the Anacostia River, which is approximately three-quarters of a mile away. The water which is used for cooling in the Capitol Building, Senate Office Building, and the two House Office Buildings is circulated through large cork-covered steel water lines which connect from the above mentioned buildings to the refrigeration plant. The water is circulated through fin type coolers in the air conditioning systems in the buildings. In this manner only the friction head of the refrigeration coolers, pipe system and cooling coil has to be overcome by the pumps.

Old House Office Building: This building is cooled by several systems located in the basement and in the attic. Several systems are of the run-around type.

Supreme Court Building: The system comprises several systems located in the basement, which employ the spray chamber type of heat transfer between the air and water. Centrifugal refrigeration machines are employed to cool the water. Spray type condensing water coolers are installed to cool the condensing water.

Library of Congress Annex Building: The air conditioning equipment consists of several systems, located in the basement and the top floor mechanical rooms, which employ the spray chamber type of heat transfer between the air and water. Centrifugal refrigeration machines are employed to cool the water. Spray type condensing water coolers are installed to cool the condensing water.

New Officers for North Carolina

April 26, 1940. The annual meeting of the North Carolina Chapter was held at Southgate Dormitory, Engineering School, Duke University, Durham, with Pres. R. B. Rice presiding. Professor Wilbur of the Mechanical Engineering School welcomed the members and guests in behalf of the University.

Guests present were introduced by Professor Rice, while the students from North Carolina State College were introduced by Prof. L. L. Vaughan of the State College faculty and member of the Chapter. Students from Duke Engineering School were introduced by F. J. Reed.

At the opening of the meeting a gavel made at the Engineering School in Raleigh was presented to the chapter by Professor Vaughan. Following this a short business meeting was held at which time several items of new and old business were discussed, and the presiding officer distributed ballots to the members advising that balloting on officers for the ensuing year would be held at this meeting. G. C. Burr nominated W. M. Wallace, II, for President and Mr. Reed for Vice-President, and suggested that these names be added to those already suggested by the nominating committee. This was duly seconded and the names were added to those already on the ballot.

At this point Arvin Page, Winston-Salem, was introduced. Mr. Page gave an interesting talk with special reference to the problems which the young engineer could expect when starting into industry, as well as some of the problems of vital interest to the engineering profession in this section of the country relating to comfort conditions in industrial plants.

Following Mr. Page's talk, T. H. Urdahl, consulting engineer, Washington, D. C., was introduced. He selected The Crimes of Omission as the topic of his talk, which proved most interesting. He dealt with various problems encountered in his work as a private consultant. Several specific instances were pointed out by Mr. Urdahl, and all present were made aware of the responsibilities on the shoulders of the individual engineer.

At the conclusion of Mr. Urdahl's talk the president announced the result of the balloting which was as follows:

President—Arvin Page
Vice-President—C. E. Petty
Secretary-Treasurer—T. C. Cooke
Board of Governors—R. B. Rice, E. R. Harding, and M. D. Brown.

The meeting was adjourned by the newly elected president, Mr. Page.

St. Louis Chapter Meets

April 9, 1940. The regular monthly meeting of the St. Louis Chapter was held at the Kingsway Hotel, with 57 members and guests in attendance. In the absence of C. F. Boester, acting secretary L. J. DuBois read the minutes of the March meeting which were approved as read.

E. E. Carlson then read the following motion which had been passed at the Board of Governors' meeting: "RESOLVED, That the Chapter President and whomever he desires to assist him, be instructed to write a letter to all chapters of the Society explaining that St. Louis Chapter feels it will lack representation on the Nominating Committee under the plan covered by Report of the Committee which will be presented at the Semi-Annual Meeting at Washington, D. C., in June, and suggesting a change in the suggested zones." R. J. Tenkonohy discussed briefly the reasons for passing this resolution.

President Tenkonohy appointed an auditing committee to go over the Treasurer's books in order to have them approved when turned over to the incoming treasurer, consisting of: P. W. Sodemann, chairman, L. Walter Moon and B. C. Simons.

J. H. Carter, chairman of the entertainment committee, announced that the spring party would be held Friday, June 7, at the Norwood Hills Country Club.

Mr. Carlson, chairman of the nominating committee, reported the following slate of officers suggested for the ensuing year: *President*—C. E. Hartwein; *First Vice-President*—D. J. Fagin *Second Vice-President*—M. F. Carlock; *Secretary*—C. F. Boester; *Treasurer*—J. H. Carter; *Board of Governors*—R. J. Tenkonohy, W. J. Oonk, B. C. Simons and L. J. DuBois.

The meeting was turned over to Chairman Hartwein of the Program committee, who announced that Ralf Toensfeldt, local consulting engineer, would talk at the next chapter meeting on the economics of air conditioning for office buildings.

Mr. Hartwein then introduced E. H. Ronsick, who ably presented and discussed the technical paper entitled, Diminishing Effectiveness of Successive Thicknesses of Insulating Materials.

Following a short recess after a discussion on this paper, Mr. Hartwein introduced the guest speaker of the evening, E. C. Webb, engineering service manager, Iron Fireman Mfg. Co., Cleveland, O. Mr. Webb presented an interesting paper on stokers, which he illustrated with slides. After a spirited discussion of the subject the meeting adjourned.

Washington D. C. Chapter President Addresses Atlanta Meeting

May 6, 1940. The regular monthly meeting of the Atlanta Chapter was held at the Biltmore Hotel, with Pres. T. T. Tucker presiding.

The research committee reported that Georgia Tech was going forward with a research project covering the application of attic fans to various residential cooling and ventilating problems. This project is being financed for the present by Georgia Tech and the Atlanta Chapter of the Society, with the hope that ultimately the ASHVE will also assist.

The Exposition Cotton Mills has agreed to permit the use of two five-room cottages of similar construction, location and exposure. One will be used as a control house and a fan will be installed in the other. Tests will be made to show the comparative results with and without an attic fan and also results from various amounts of air handled and different methods of distribution of the air.

The secretary read a letter from the St. Louis Chapter offering objections to the proposed new plan of selecting the nominating committee. After considerable discussion the committee composed of Messrs. Boyd, Koch and Kent was appointed to study the matter and advise the chapter delegate the position he should take at the Semi-Annual Meeting, Washington, D. C.

The secretary was instructed to write a letter inviting the *Smoke Prevention Association* to hold their 1941 convention in Atlanta.

Prof. R. S. King, head of department of mechanical engineering, Georgia Tech, and chairman of the engineers advisory committee on smoke abatement, was the principal speaker. He analyzed the ordinance recommended by the committee and gave an interesting explanation of how they reached their conclusions. Following a discussion the meeting was adjourned.

April 4, 1940. The regular monthly meeting of the Atlanta Chapter was held at the Biltmore Hotel, with Pres. T. T. Tucker calling the meeting to order at 8:00 p. m.

The research committee reported that the number of research projects under consideration for joint action with Georgia Tech had been reduced to three, and from these three a final decision on one project was expected in the near future. S. W. Boyd reported briefly for the code committee on the progress of the smoke abatement campaign.

The guest speaker of the evening, T. H. Urdahl, president of the Washington, D. C. Chapter, was then introduced. Mr. Urdahl chose as his subject Crimes of Omission, devoting his talk principally to a discussion of some heating and air conditioning jobs which he had observed where unsatisfactory operation resulted from the installation of insufficient or inadequate equipment. His talk was followed by an interesting discussion, and there being no further business, Secretary Kent reported the meeting adjourned.

Mechanical Equipment in Buildings Discussed at Illinois

March 11, 1940. Pres. Tom Brown called the March meeting of the Illinois Chapter to order with 77 members and guests in attendance. At the opening of the meeting President Brown appointed Messrs. Philippi, Pitcher and Sunderland as tellers to count the ballots for members to serve on the nominating committee. The minutes of the February meeting were dispensed with, and President Brown called attention to the Midwest Power Conference and urged as many members as possible to attend. He then announced that F. E. Giesecke, College Station, Tex., president of the Society, was scheduled as the guest for the April meeting.

C. M. Burnam, Jr., introduced the speaker of the evening, R. E. Hieronymus, general superintendent, Aldis & Co., who discussed mechanical equipment in buildings. He opened his remarks with a discussion of heat economy in buildings as correlated with the degree-day chart. He explained that experience has taught that effective heat economy is provided in the use of the degree-day and Erlenborn charts. He pointed out that efficiency of operation was dependent upon two factors, economy through basement process (that is, fuel burning equipment, type of fuel, etc.) and *upstairs* utilization of steam, and it was to the second of these factors that the speaker devoted most of his remarks. He took as a specific example a building with a content of approximately 2,300,000 cu ft and with an enlarged copy of the Erlenborn Chart traced through the procedure for a month's operation, with particular reference to how the degree-day formula could be applied.

Mr. Hieronymus reported on a recent survey of 30 Chicago office buildings, which indicated that the average steam consumption for 1,000 cu ft of volume was 0.5838 lb of steam in one-pipe differential systems and 0.5800 lb of steam in two-pipe systems, provided daily checks of the degree-day chart were made. However, the buildings making no check averaged 0.761 lb, buildings making a monthly check 0.717 lb, and buildings making a daily check 0.592 lb. Mr. Hieronymus pointed out the usability of the chart regardless of the type of building, fuel used, or even the climate.

The speaker then went into the subject of air conditioning, using as a basis the Monroe-Dearborn two-story tax-payer. He gave a comprehensive description of the plant which provides complete year-round air conditioning to a rentable area of 39,300 sq ft.

Mr. Hieronymus then called on C. N. Bailey, who is associated with him in the operating department of Aldis & Co., who discussed a color code used in the operating chart of the Monroe-Dearborn Building, and pointed out its benefits as to economy and also as a guide to the operating engineer.

Great interest in the talks was evidenced by the open discussion which followed. Following the discussion President Brown called on Mr. Philippi to report for the tellers on ballots for the nominating committee. He reported the following elected to serve on the committee: Messrs. Aeberly, Bishop, Brown, Hayes, Howatt, Johnson and Vernon. The meeting was adjourned following this report.

Carnegie Tech Elects New Officers for ASHVE Student Chapter

April 11, 1940. The meeting was called to order by Pres. R. L. Smith, and the minutes of the last meeting were read, and as there were no corrections or additions, new business was brought before the members.

The first order of business was the election of officers for the new school year, 1940-1941. It was decided to nominate separately for the offices of president and vice-president, and the election be made for only one office at a time. The result of the election is as follows.

President—E. J. Long
Vice-President—H. J. Hample
Secretary-Treasurer—H. S. Jones

The meeting was then turned over to the newly elected president, Mr. Long, who suggested a picnic for the group, setting the date tentatively as the first Saturday in May. A committee was then appointed to make arrangements for the get-together.

At the conclusion of the meeting the members held a joint meeting with the students of the *American Society of Mechanical Engineers* at which time they witnessed the showing of a movie entitled Flow, which was obtained through the courtesy of the Crane Co. At the conclusion of the picture the entire group retired for refreshments and the meeting was adjourned.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 29 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, the Council, urge the members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by June 16, 1940, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
AMBROSE, E. R., Air Cond. Engr., American Gas & Elec. Serv. Corp., Brooklyn, N. Y.	D. W. McLenegan Elliott Harrington	F. H. Faust F. O. Urban
ANOFF, S. M., Engrg. Dir., DeVry & Co., Chicago, Ill.	G. L. Larson J. Dorrans (*Non-Member*)	P. H. Hyland (*Non-Member*) J. N. Mitchell (*Non-Member*)
BEALS, D. E., Supervising Engr. and Estimator, M. F. Fischer & Son, Norman, Okla.	F. X. Loeffler A. R. Morin	R. G. Dolan E. W. Gray

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
BELFORD, L. DUB., Div. Supvr., Minneapolis-Honeywell Reg. Co., Philadelphia, Pa.	H. F. Dever C. B. Eastman	G. D. Guler L. C. Davidson
COOPERMAN, EDWARD, Student, Carnegie Inst. of Tech., Pittsburgh, Pa.	C. M. Humphreys T. F. Rockwell	P. A. Edwards R. L. Smith
COTTRELL, W. H., Gen'l. Mgr., Home Owners Heating Equipment Co., Minneapolis, Minn.	F. H. Schernbeck H. P. Wallace, Jr.	P. Hitchcock A. J. Huch
ELLIS, G. W., Engr., Acme Heating and Ventilating Co., Chicago, Illinois.	J. J. Finan John Howatt	E. J. Finan E. B. Ericsson
GJERTSEN, GEORGE, Student, Technicians Inst., Brooklyn, N. Y.	M. W. Wolin M. M. Kabili (*ASME*)	A. W. Akers (*Non-Member*) F. W. Heisinger (*Non-Member*)
KILLIAN, W. J., Sales Rep., Herman Nelson Corp., Moline, Ill.	G. L. Leupold O. W. Motz	I. B. Helburn H. K. Jennings
KREINER, JACK, Owner, Jack Kreiner Co., New York, N. Y.	Jack Miller W. W. Timmis	Philip Wolf Alfred Hering
LABONNE, HENRI, Mgr. Htg. Div., Codere, Ltd., Sherbrooke, Que., Can.	A. F. LaMontagne P. A. Standring	H. G. Hill C. W. Johnson
LEVINE, L. J., Asst. Engr., Paragon Oil Burner Corp., Brooklyn, N. Y.	J. J. Morro B. H. Schulze	W. R. Fidelius H. L. Hosking
LIGE, W. W., Resident Mgr., Bell and Gossett Co., Chicago, Ill.	J. H. Shrock Henry Mathis	J. W. Mathis H. F. Gain (*Non-Member*)
MALLY, C. F., Cons. Engr., Mally & Co., Ferndale, Mich. (*Advancement*)	S. S. Sanford G. D. Winans	W. C. Randall E. H. Clark
MARKET, J. W., Assoc. Naval Archt., U. S. Maritime Comm., Washington, D. C.	F. E. Spurney John James	I. M. Day F. A. Leser
MINER, H. H., Partner, Miner Supply Co., Red Bank, N. J.	I. E. Brex A. H. Schroth	K. L. Mytinger Sidney Samuels
NOBLE, MILNOR, Chief Engr., Aerofin Corp., Syracuse, N. Y. (*Reinstatement*)	Arthur Ritter R. A. Wasson	W. E. Heibel R. H. Carpenter
PLATZ, J. F., Mgr., and Sales Engr., J. M. & L. A. Osborn Co., Cleveland, Ohio.	C. M. H. Kaercher J. Fitzwilliams (*Non-Member*)	L. E. Slawson E. W. Gray
RANDOLPH, H. F., Vice-Pres., Internatl. Heater Co., Utica, N. Y.	J. F. McIntire A. P. Kratz	Clifford Strock M. K. Fahnestock
ROPER, R. F., Pres., Pleasantaire Corp., Washington, D. C.	S. L. Gregg A. C. Crawford	G. R. Walz F. A. Leser
RYAN, H. J., Pres., Harold J. Ryan, Inc., New York, N. Y.	M. F. Rather Joe Wheeler, Jr.	F. E. W. Beebe H. L. Baker, Jr.
SAMPSON, W. D., Cons. Engr., Will D. Sampson & Associates, St. Louis, Mo.	C. F. Boester, Jr. Paul Sodemann	W. P. Norris L. W. Moon
SHELL, JACK, Chief Engr., Air Cond. Dept., Jefferson Amusement Co., Beaumont, Tex.	E. W. Fuller John Everetts, Jr.	Rothwell Woodward Herman Worsham
SKINNER, ALTON, JR., Htg. & Air Cond. Engr., Bagwell Plbg. & Htg. Co., Durham, N. C.	W. M. Wallace, II T. C. Cooke	C. E. Petty H. H. Hill
STEVENS, E. K., Associate Mgr., Heating & Ventilating Exposition, New York, N. Y.	C. F. Roth A. V. Hutchinson	A. J. Offner W. L. Fleisher
STUART, W. W., Owner, W. W. Stuart Co., Des Moines, Iowa	F. E. Triggs T. R. Johnson	Bowen Campbell C. W. Helstrom
TOENSFELDT, RALF, Cons. Engr., St. Louis, Mo.	M. F. Carlock Paul Sodemann	J. H. Carter W. J. Onk
VIRRILL, G. A., Chief Engr., The University Club, New Rochelle, N. Y.	F. G. Walther Walter Tusch	D. A. MacWatt P. B. Gordon
WEBSTER, C. C., Pres., John Hankin & Bro., New York, N. Y.	J. C. Fitts A. C. Buensod	W. L. Fleisher M. C. Giannini

CANDIDATES ELECTED

In the past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

EVANS, RICHARD W., Mgr., Comm. Air Cond. Dept., Conditioned Air Equip. Co., St. Paul, Minn.

REPP, HARRY L., Br. Mgr., U. S. Radiator Corp., Cleveland, Ohio (*Reinstatement*).

ASSOCIATES

BAHLMANN, WILLIAM F., Br. Mgr., Holland Furnace Co., Richmond, Va.

RUNGE, CARL H., Mgr., Sunbeam Dept., American Rad. & Stan. Sanitary Corp., Milwaukee, Wis.

STUDENT

HAWES, HAROLD D., Student, Mass. Inst. of Tech., Brookline, Mass.

NOW—This One Unit-heater Motor for Six Applications to Simplify Stocking and Installation Problems

One motor for 110-volt or 220-volt, single-speed operation

This same motor with suitable control for 110-volt or 220-volt, two-speed operation

This same motor with a G-E speed regulator for 110-volt or 220-volt variable-speed operation

G-E Motor for Direct-connected Fans and Blowers

Enjoy This Flexibility by Using G-E Fan and Blower Motors

YOU will like this permanent-split capacitor-motor for unit heaters and blowers because it will greatly simplify your application. Using this motor you get the benefits of standardization, plus a motor that will fit practically every one of your direct-connected fan jobs. This motor is dual voltage—it will operate on either 110 or 220 volts—and can be base mounted, resilient mounted, mounted on extended through-bolts, or mounted on a pedestal or saddle adapter. Addition of a simple control gives two-speed operation on either voltage range. If neither single- or two-speed operation will fit your application, the motor speed can be "tailored" to your needs by use of an inexpensive speed regulator.

Actually, you get six motors in one—three speed-ratings in two voltage ranges. Eight horsepower ratings will fill all your needs—1/20, 1/12, 1/8, 1/6, 1/4, 1/3, 1/2, and 3/4 hp. Picture for yourself how this simplifies your stocking and installation problems and lowers your costs.

The only attention that this motor requires is infrequent oiling. It is totally enclosed and rated at 55C without air over the motor. Adequate provision is made for end thrust. Get additional information today. Mail the coupon now.

OTHER G-E FAN-DUTY MOTORS

Equip your furnace air conditioners, attic ventilating fans, and similar belt-driven applications with long-lived General Electric motors. They too, have cast-aluminum rotors that are practically indestructible, bearings that require only occasional oiling, and stators that are resistant to moisture, and mild acids, and alkalies. They are generally furnished with resilient mounting but can be supplied with other types of mounting if necessary. The features of these motors and their reputation for giving good service will add greatly to the sales appeal and prestige of your product.

General Electric, Section 070-275A
Schenectady, N. Y.

Please send me additional information on General Electric motors:

For direct-connected fan and blowers
For belt-driven fans and blowers

Name.....

Firm.....

Street.....

City..... *State*.....

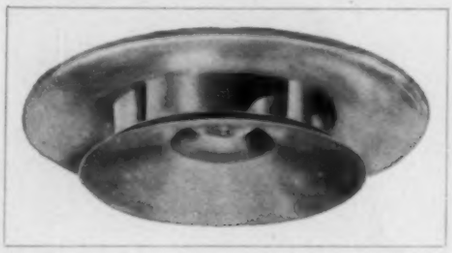
070-275

GENERAL ELECTRIC

Equipment
DEVELOPMENTS

Ceiling Air Distributor

No. 1869**—A new air distributor recently announced is in the form of a ceiling fixture of modern design which can be used in conjunction with lighting fixtures. It is designed to distribute any given volume of air at any desired velocity, according to the manufacturer.



It consists of a ceiling flange which slips into the duct connection. A deflecting cone is mounted co-axially and spaced from the flange to form an emitting nozzle within which opening are placed curved deflecting vanes. A second hollow deflecting cone, extending beyond the edge of the principal cone, is spaced from the principal cone and forms a tangential injector nozzle.

According to the maker, this construction accomplishes three things necessary to balanced distribution of conditioned air: (1) A circulatory motion which evenly distributes the conditioned air. (2) A vortex, forming in the room directly below the device, to draw the room air to the distributor. (3) An injector to provide a recirculation of the room air with the conditioned air.—Charles Demuth & Sons, 112-07 New York Blvd., Jamaica, N. Y.

Portable Printer

No. 1870—The new "Elpro" portable printer has been designed to reproduce engineering drawings, letters, maps, charts, printed forms, etc., up to a maximum size of 12x18 in. Exposure is made by placing the drawing face up on the sensitized paper and locking both in a contact frame hinged to the cabinet proper. The light source consists of six specially designed lamps; exposure is regulated automatically by a time release switch, and usually takes 2 to 4 min, depending upon the type of original used. The print is developed dry by placing it in a developing chamber behind the reflector. Development also takes from 2 to 4 min.

This equipment operates on an ordinary lighting circuit of 110 volts a-c or d-c.—Ozalid Corp., Ansco Rd., Johnson City, N. Y.

For your convenience in obtaining more information about any of this equipment, see coupon on page 130. Add the new products and companies listed here to your Directory Section which you received in your January, 1940, HEATING, PIPING AND AIR CONDITIONING and thus keep your records of sources of supply up to date throughout the year . . . Single asterisk (*) indicates equipment not listed in Directory Section; double asterisk (**) equipment and manufacturer not listed

Oil Burners

No. 1871*—A new line of three "Spiralaire" oil burners for steam, hot water, or warm air heating systems in commercial and industrial buildings and homes has been announced. On steam systems the units are rated at 1720, 2690 and 3400 sq ft of radiation. Maximum oil rates are 6, 8½, and 12 gph, respectively. Motors are ⅙ hp on the smallest unit and ¼ hp on the two larger ones. Hot water rating of the smallest unit is 2710 sq ft and the other two are rated at 4300 and 5440 sq ft. When applied to forced warm air heating systems the units are rated at 408,000, 645,000 and 815,000 Btu per hr.

Efficiency and economy are provided by an unusual air control system in which a spiral air stream and a volatile air-oil mixture are combined for complete combustion, the maker states. A uniform flame is maintained by locating the regulator behind the fan discharge instead of at the fan intake. The air regulation and an adjustable diffuser permit the flame to be shaped to the firebox, it is said.—Westinghouse Electric & Mfg. Co., East Springfield, Mass.

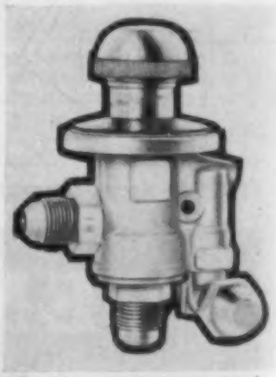
Low Water Cut-Offs

No. 1872*—New all-electric, low water cut-offs are for boiler mounting and supplement the maker's gage glass mounting type. They have no moving parts, glands, or seals under pressure, and electrode chambers are small in volume in order to minimize any tendency of suspended particles to settle and mud up.

The only moving part is the armature and tube. Line and voltage models carry double voltage coils, permitting either 115 or 230 volt a-c connection on the job. Alarm circuit is optional on line voltage models.—General Controls Co., 700 W. Ivy St., Glendale, Calif.

Suction Pressure Regulating Valve

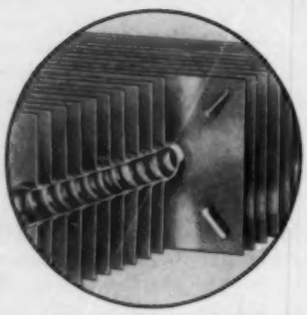
No. 1873—A new suction pressure regulating valve for refrigeration systems has been designed for use on single installations to regulate the pressure at the tail of the evaporator. It permits the maintaining of the evaporator pressure at a desired level, regardless of changes in load or variations in suction pressure on the outlet side of the regulating valve, according to the maker. It may also be used where two or more evaporators are operating at different temperatures with a single condensing unit. The valve may be used on either flooded, semi-flooded or dry expansion systems, with either "Freon," methyl chloride or sulphur dioxide.



McQuay

AIR CONDITIONING COILS

FOR EVERY PURPOSE



McQuay Frictional Bond Coil Construction

WHETHER it be a single unit installation or a large central system, you will find a McQuay Air Conditioning Coil to exactly meet your requirements. McQuay Air Conditioning Coils are constructed for high pressure operation. All have the famous and exclusive frictional bond construction which means increased efficiency and longer life. In all parts of the country and under widely varying conditions, McQuay Air Conditioning Coils have for years given the kind of service you can expect from a superior product. They are available in an exceptionally wide range of types and sizes to meet every possible application. McQuay, Inc., 1601 Broadway St., Minneapolis, Minnesota.

PIONEER MANUFACTURERS OF EXTENDED SURFACE

McQuay INC.

Air Conditioners...Air Conditioning Coils...Blast Coils...Blower Coolers...Comfort Coolers...Cabinet Radiation...Concealed Radiation...Evaporative Condensers...Indoor Cooling Towers...Ice Cube Makers...Icy-Flo Accumulators...Refrigerating Coils...Room Coolers...Unit Heaters...Unit Coolers...Water Cooling Units

. . . WITH ANDERSON SUPER-SILVERTOP TRAPS

Detour piping of inverted bucket traps is wasteful, time-consuming and unnecessary. Straight-through piping with Anderson Super-Silvertops is quick—saves fittings and labor—is neater in appearance. This *engineered* steam trap simplifies the piping (either elbow or straight-in-line) without using trouble-breeding split gaskets or cored passages.

Super-Silvertop has a guided, bucket-on-a-track that insures constant, perfect parts alignment and at the same time gives equal capacity in a smaller trap. (This reduces trap costs.) Tough Anderloy valve and seat insure against valve leakage for many years. Pipe connections in the head make inspection easy and fast, with trap still on the line.

Get the complete story on all these points —write today for details and prices.

THE V. D. ANDERSON CO.
1949 West 96th Street • Cleveland, Ohio

Super-Silvertop STEAM TRAPS

The valve is of the throttling type, tending to close off gradually as the evaporator pressure is reduced beyond a certain point. A feature is a convenient pressure setting adjustment. On the collar below the adjusting knob is a scale graduated in pressure. By turning the knob to correspond with the markings, an approximate pressure setting can be secured immediately. Then, after the system has had an opportunity of settling down, exact pressure settings can be secured by means of a gage.—Automatic Products Co., 2460 N. 32nd St., Milwaukee, Wis.

Air Conditioning Unit

No. 1874**—The "Multi-Zone" air conditioning unit is offered for conditioning two or more zones in apartments, stores, offices, residences, and other establishments. Designed for year 'round use, it incorporates built-in zone control for cooling or heating, either standard refrigerant coils being incorporated or cold water circulated through the units for cooling.

Two models are available rated at 120,000 and 150,000 Btu per hr heating capacity, and 700 and 875 cfm, respectively—Micheli Air Conditioning Co., Inc., 1725 State St., Schenectady, N. Y.

Pillow Block With One Piece Housing

No. 1875—A one piece steel housing pillow block for shafts of $1\frac{1}{16}$ to $1\frac{7}{16}$ in. diameter has been developed. The patented design results in a quiet, light weight, bearing, the maker states. Features include selective mounting positions, constant self alignment, and self lubrication.

The entire assembly, consisting of three parts—the housing, a new machined cast iron ball with large oil reservoir, and a patented bronze bushing with graphite filled grooves to provide lubrication—is cadmium plated to resist corrosion, and is assembled ready for use without adjustment.—Randall Graphite Products Corp., 609 W. Lake St., Chicago, Ill.

Centrifugal Spray Nozzle

No. 1876—A non-clogging centrifugal spray nozzle with a large orifice of the "Whirljet" type recently announced has a 2.3 gpm capacity with a 45 deg included spray angle at 10 lb pressure. Standard stock construction is 18-8 stainless steel and other materials can be specified.

This nozzle is offered for use in air conditioning and in industrial applications where a concentrated centrifugal non-clogging spray that carries a long distance is required, according to the manufacturer.—Spraying Systems Co., 4021 W. Lake St., Chicago, Ill.

Soldering Iron Furnace

No. 1877—A new soldering iron furnace has been developed to meet the need for a portable furnace that can be carried to a spot where the irons are to be used, the maker says. It holds a pair of coppers one above the other, directly over the flame, including all sizes up to a 12 lb pair.

The furnace is used with a cylinder of fuel connected by a 25 ft rubber hose. Its over-all length is 14 in. and the weight is $15\frac{1}{4}$ lb.—Insto-Gas Corp., 1900 E. Jefferson St., Detroit, Mich.

Mercury Relay

No. 1878*—Features of a new mercury relay include an unbreakable metal body and the displacement principle with solenoid actuation, the maker states. The contact structure is hermetically sealed, making the relay suitable for use in corrosive or explosive atmospheres. The metal body is specially treated to hold a gas at a pressure of four atmospheres.

Manufactured to meet ordinary requirements, the relay is also available for special requirements up to 200 amp capacity. Relay tube, or tube and solenoid, may be ordered separately.—Durakool, Inc., 1010 N. Main St., Elkhart, Ind.

Pneumatic Condensers

No. 1879—A new line of "pneumatic" or evaporative condensers was announced recently which operate on "an improved evaporative principle" and are suitable for "Freon," ammonia and other refrigerants. Available in 15 standard sizes up to 100 tons capacity, they are offered for use in air conditioning and refrigeration and may also be had in larger sizes.

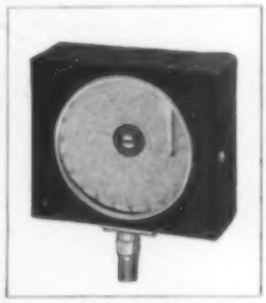
Features of construction include—according to the manufacturer—the use of prime surface throughout; to facilitate installation, the units can be easily dismantled—the fan section, coil section and base are bolted together with the screened air inlet box and the pump removable. Each piece is a separate unit and if required the condenser can be shipped knocked down.

The amount of make-up water to replace that evaporated in these units approximates 1.5 to 1.6 gal per ton per hr.—Hess Warming & Ventilating Co., 1211 S. Western Ave., Chicago, Ill.

Miniature Recorders

No. 1880—A line of miniature recorders for temperature, pressure, humidity and cycle operation has recently been placed on the market.

The recording thermometer incorporates a bimetallic spiral and records temperature wherever it is placed. It is available in six different temperature ranges, from minus 20 to plus 25 F with 1 deg divisions up to plus 20 to plus 110 F with 2 deg divisions. The recording gage is of the bourdon tube type and may be had in six pressure ranges from 0 to 15 lb with ½ lb divisions up to 0 to 300 lb with 5 lb divisions, and also in two compound types which also record vacuums.



The humidity instrument will record with an accuracy of approximately 2 per cent plus or minus between the ranges of 20 to 85 per cent relative humidity, the maker states, and is suitable for use between 32 F and 125 F. The cycle recorder shows alternate periods of "on" and "off" and is designed for direct connection across the power line.—Jas. P. Marsh Corp., 2073 Southport Ave., Chicago, Ill.

Multibreaker Case Construction

No. 1881—A change in the case construction used with the manufacturer's "Type MB" multibreaker assemblies has been announced. The device now has an insulated, groundable neutral combining the construction of the insulated and grounded neutral. Inserting a screw in a tapped hole of the insulated neutral bar grounds the neutral and the case.

This new construction is primarily an aid to electrical wholesalers and contractors, the maker states. The wholesaler need

Now in 3, 5, 7½, 10 and 15 Ton Capacities

CURTIS Packaged Air Conditioners

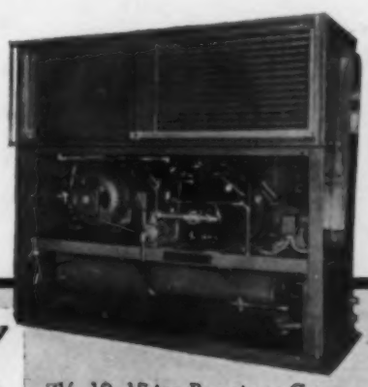
● With a wide range of from 3 to 15 tons capacity, Curtis Packaged Air Conditioners now meet the demands of a variety of markets with complete mechanically refrigerated air conditioning at low cost.

Every type of retail establishment is now a prospect for this Curtis equipment, for they can profit from the advantages of air conditioning without costly installation charges or disturbance to fixtures.

The Curtis Store and Office Cooler and the Curtis Remote or Central Type Air Conditioner are completely factory designed and built packaged units that cool, dehumidify, circulate and filter the air. They are quickly and easily installed, readily financed, and are adaptable for heating if desired.

The demand for Curtis Packaged Air Conditioning is growing every day. Write to Curtis for complete information on the Curtis line.

Meet ALL Requirements



7½, 10, 15-ton Remote or Central Type Air Conditioner

3 and 5-ton Packaged Type Air Conditioner

Curtis Refrigerating Machine Company

Division of Curtis Manufacturing Co.

1950 Kienlen Ave. St. Louis, Mo.

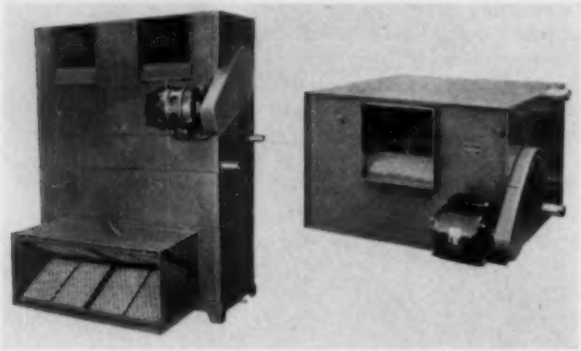
Established 1854

CURTIS REFRIGERATION AIR CONDITIONING and COMMERCIAL

carry only one type of device in stock; the contractor need not be concerned with the problem of which type of neutral construction is required.—Cutler-Hammer, Inc., N. 12th St. and W. St. Paul Ave., Milwaukee, Wis.

Air Conditioning Units

No. 1882—A line of air conditioning units, based (the maker states) on 35 years of research and experience in the heat transfer field, are of the complete cabinet type and are furnished



for either floor or ceiling mounting. They are available in a variety of sizes and range from 2 to 30 tons cooling and 65,000 to 1,280,000 Btu per hr heating capacity.

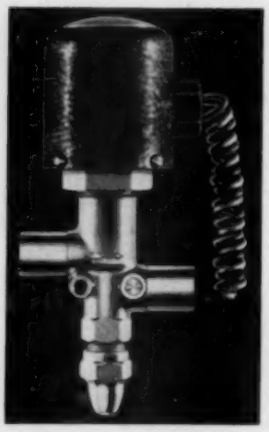
The "Turbo-Fin" type coils are of all copper construction with fins bonded to the tubes by metallic fusion; they are tested under 300 lb pressure. Cabinets are of heavy gage steel, the larger units being made up of three or more sections—fan section, heating coil section, cooling coil section and base—to allow for portability and accessibility. The cabinets are lined with sound deadening and heat insulating material.

Fans are of the centrifugal type and filters are of fiber glass. —Kramer Trenton Co., 626 Brunswick Ave., Trenton, N. J.

Starting Timer for Conditioning Units

No. 1883—A new automatic starting timer for portable air conditioning units is expected by its maker to advance the conveniences of this type of air conditioning. It makes possible the starting of the air conditioner at any hour desired so that a bedroom or office will be cooled at any specified time it may be wanted for use. At any time within the previous twenty-four hours the timer can be set so that one or two hours before the room is to be used, it automatically starts the operation.

The unit is simply installed, being wired in series with the electric power supply to the air conditioner.—Philco Radio & Television Corp., 3710 N. Broad St., Philadelphia, Pa.



Solenoid Refrigerant Valve

No. 1884—Designed for both liquid and suction line applications, a new solenoid refrigerant valve, can be used on "Freon," methyl chloride or sulphur dioxide systems. It will lift against rated pressure at 85 per cent of rated voltage, and pilot operation provides increased capacity and simple, positive action, the maker states. Quiet operation is accomplished by means of a three point stop used in conjunction with a shading coil. The shading coil is a shorted electrical conductor in the magnetic path, which creates a

IT WILL PAY YOU TO SPECIFY
RIC-WIL PRE-SEALED INSULATED PIPE UNITS
FOR UNDERGROUND AND OVERHEAD PIPING

STABILITY
STRENGTH
SIMPLICITY
REAL PIPE SUPPORT AND GUIDE SCREW INTO CONDUIT — REMOVABLE
PIPE AND ITS COVERING FREE FROM ANY LOAD ON THE CONDUIT
HEAVY ASPHALT SHELL IS OUTSIDE OF AND SUPPORTED BY STRONG ARMCO CONDUIT
CROSS SECTION
DURABLE WATERTIGHT ENGINEERING
RIC-WIL INSULATED PIPE UNITS

BECAUSE—

The Armco Helical Conduit has the inherent PERMANENT strength required—durable, watertight and lightweight. Furnished with any kind of pipe or insulation. A complete system, in standard lengths, which will stand any engineering test. Compare Ric-wiL details with other systems and you will be convinced. Write for latest bulletin.

Strength Underground

THE RIC-WIL CO.
CLEVELAND, OHIO
AGENTS IN PRINCIPAL CITIES

Strength Overhead

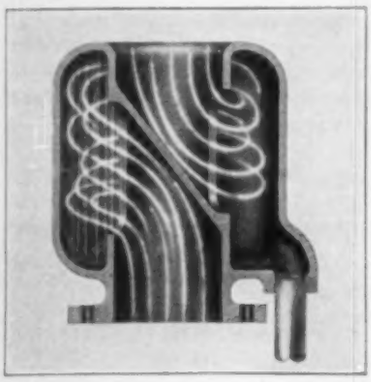
magnetic flux out of phase with the original flux. This out-of-phase flux set up by the shading coil breaks up the plunger pulsations of the alternating current by holding the plunger rigid during the zero period of the voltage cycle.

Another interesting feature of the valve is the manner in which inlet and outlet connections have been offset—the inlet above and the outlet below the valve seat. This has been done to minimize restriction of the refrigerant flow and increase the capacity of the valve at a given pressure drop.

The valve can be installed on either 5/8 or 7/8 in. OD tubing; reversible mounting brackets are furnished with each unit at no additional cost. A manual opening feature permits opening the valve during current failure.—Automatic Products Co., 2460 N. 32nd St., Dept. HPC, Milwaukee, Wis.

Exhaust Heads

No. 1885—A new exhaust head insures the separation of condensate and oil from steam discharged to atmosphere and thereby prevents raining of water and oily condensate upon the roof or ground below, at the same time discharging clean, dry steam noiselessly, the maker states.

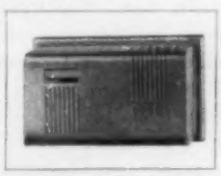


The head incorporates the principles of baffle type steam separators used for removing oil and moisture from steam lines. Large port area produces low steam velocity and minimizes pressure loss. Steam is whipped sidewise after passing through port and causes projection of entrainment against ribbed baffle surfaces. The high ribbed baffles exert a scrubbing action in addition to the centrifugal purging force.

The exhaust head is of one piece semi-steel construction for 4 to 12 in. sizes and of welded plate for larger sizes.—Cochrane Corp., 3161 N. 17th St., Philadelphia, Pa.

Room Humidistat

No. 1886—Designed to conform with the trend in modern architecture and finished in silver bronze, the new room "Humid-U-Stat" is a pneumatic hair element humidity controller designed for wall mounting. It is equipped with a temperature compensator to maintain calibration so that it will control at the selected relative humidity, even though the temperature changes.



The humidistat may be used as a direct or a reverse acting control by a simple adjustment. Also, the throttling range may be adjusted on the job to prevent the wide variations in humidity which sometimes result from controls "hunting." The instrument is available in the scale range of 20 to 80 per cent relative humidity with scale markings 20, 50, and 80. The throttling range is adjustable from 2 to 30 per cent relative humidity. The instrument may be mounted flush on a wall box or on the surface of a surface box.—Minneapolis-Honeywell Regulator Co., 2701 Fourth Ave., S., Minneapolis, Minn.

Flow Meter for Steam, Water, Air or Gas

No. 1887—A simplified "Adsco" flow meter operating on a "free floating moving container" principle for the metering of steam, water, air or gas, uses an orifice plate in the pipe line and

PIONEERING ILG LEADERSHIP

"Firsts"

NUMBER 1 OF A SERIES

WITH THE SELF-COOLED MIRACLE MOTOR THAT "BREATHES!"

DIRECT-CONNECTED PROPELLER FANS

First to place direct-connected propeller fans on a production basis, ILG has maintained continuous leadership in the field since 1906. Then, as now, the patented motor is "self-cooled" by fresh, clean air, saving 5 to 10% on power costs . . . combines LOW OPERATING COST of open motor with PROTECTION of fully enclosed motor . . . never "gums up" from contact with foul air . . . is direct connected to fan, avoiding wasteful friction losses . . . requires little or no maintenance . . . runs at slow speeds for smooth, quiet operation, minimizing vibration and wear . . . is built by ILG specifically and solely for ILG Propeller Fans.

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★ Popularized direct-connected blowers—patented 1910
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★ Variable air control for blowers—1926
★ Type C (condenser-type) Motors—1925
★ Penthouses or power roof ventilators—1915
★ Automatic shutter—1907
★ Motor operated shutter—1918
★ Solenoid operated shutter—1907
★ Propeller fan steam unit heater—1916
★ Self-contained electric unit heater—1917
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★ Portable type kitchen ventilating fans—1918
★ Built-in type kitchen ventilating fans—1925
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★ Rugged, heavy-duty, precision-built framework.
★ Dynamically balanced fan wheel—deeply cupped, highly efficient blades.
★ Certified Ratings in accordance with Standard Test Code of NAFM.
★ Send today for Catalog No. F-482.

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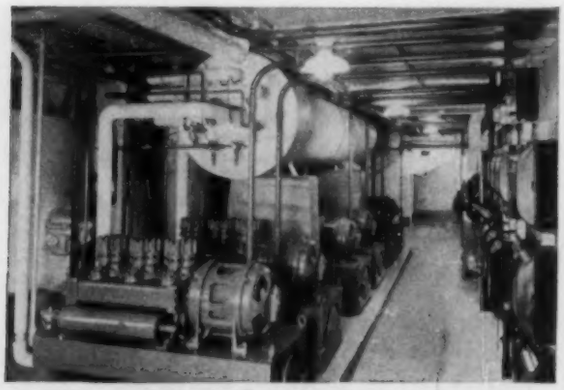
ASSURES EFFICIENT COOLING

You can be absolutely certain of cooling all the chilled water required for cooling systems by installing a Patterson Freon Cooler. That it will deliver at rated capacity continuously has been proved in hundreds of installations.

The reason for the dependable operation of Patterson Coolers is that every one is designed and built to meet the requirements of each individual job by engineers who have our experience of 60 years to guide them.

Write for a copy of our Freon Cooler catalog.

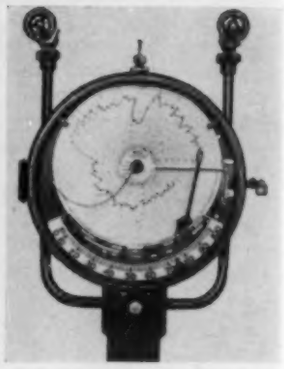


Patterson Freon Cooler in a western office bldg.

THE PATTERSON-KELLEY CO., INC
107 Warren St. East Stroudsburg, Pa.

Patterson Freon Water Coolers

records the flow on a large, evenly divided chart by means of a frictionless mechanism. Integrating counters and illuminated indicating scales are fitted when specified. All charts and counters show the flow directly and no factor has to be applied to the readings. The meter maintains its accuracy under severe operating conditions and cannot be damaged by overloads or reverse flows, according to the maker.



The internal moving parts comprise a magnet attached to a mercury container suspended from a spring. A fixed, internally shaped bell surrounds the lower portion of the magnet and forms a seal with the mercury in the container beneath it. The movement of the container is directly proportional to the flow through the orifice, and follower magnets in the external recording mechanism transmit the movement to a pen arm.

The meter is offered in four types, and an auxiliary pressure recorder can be fitted to any model to record the working pressure on the same chart as the flow.—American District Steam Co., Bryant St., North Tonawanda, N. Y.

Magnetic Gas Valves

No. 1888—A new series of single port magnetic gas valves in four sizes (⅛, ¼, ⅜ and ½ in.) has been expressly developed for the control of floor furnaces, gas humidifiers, safety pilots, or the control of diaphragm valves.

Operation is by flapper type armature. Valve port has metal to metal ground face, with self-adjusting valve made of monel. Internal parts are electrically tinned to guard against corrosion.

The valves can be supplied in line voltage (110 volts) or low voltage (20 volts). They are of neat appearance and silent in operation, says the maker.—Julien P. Friez & Sons, 4 N. Central Ave., Baltimore, Md.

Blow Off Muffler

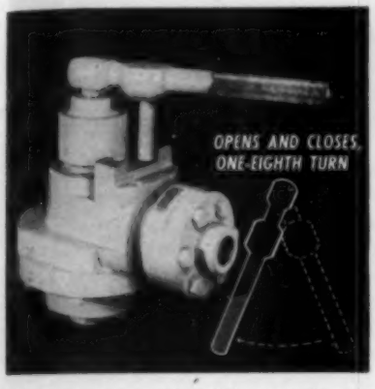
No. 1889—For separating sludge and water and dissipating pressure from blow off lines in steam plants, a new centrifugal muffler has been developed. By its use, steam can be vented in the boiler room or outside through a sheet metal pipe, and the water can be released through an open floor drain or direct to a sewer connection, the maker states.

Many safety codes prohibit boilers from being blown down to sewers and directly connected to sewer lines because high temperatures of steam entering sewers cause expansion and force apart the joints of sewer pipe. With this new muffler, the blow down on entering the inlet sets up a centrifugal action which separates sludge and water and permits vapor to rise and slowly drift out through the vent. Swirling action keeps the muffler clear of sludge and sediment. The outlet of the muffler being always open prevents the building up of dangerous boiler pressures, according to its manufacturer.

This muffler may be placed in any position within a boiler house or over a boiler setting, or on the roof, with a downspout leading to the sewer or sump, and a vent to the stack or outside of the building. The entire installation weighs 50 lb.—Sullivan Valve & Engrg. Co., 910 S. Arizona St., Butte, Mont.

Hydraulic Valves

No. 1890**—A new series of "Hydra" valves for use in hydraulic presses and machinery, may be used on water, steam and oil lines having pressures up to 4000 lb per sq in. Only one-eighth turn of the operating handle is required to open and close the valve. During this operation, the four stainless steel balls that close the valve are automatically engaged into port holes due to pressure on the line. There are no valve seats to regrind. Internal parts are of stainless steel construction.



The valves are operated by hand or by electric solenoids with pushbutton control. There are three body types—brass, bronze and steel—and standard sizes include ½, ¾, 1, 1¼, 1½ and 2 in. diameters.—Albright Equipment Co., 915 Crafts Bldg., Pittsburgh, Pa.

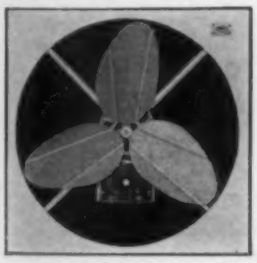
Heating Convectors

No. 1891—A new and novel feature of a 1940 line of copper convectors is the method of packaging; heating elements and fronts are packed in individual cardboard cartons to assure protection until the product is installed. Rating of the hot water convectors is given in Btu's and pricing is on the unit rather than the square foot basis.

The heating elements used in these convectors are of all copper construction, contact between fins and tubes being made permanent by a metallic bond. The shape of the tubing is designed to combine minimum resistance to air flow with maximum contact with fins and ample capacity for the heating medium, according to the manufacturer. These elements will work equally well with gravity and forced circulation hot water and one or two pipe steam jobs, the maker states.—Tuttle & Bailey, Inc., Corbin Ave., New Britain, Conn.

Ventilating Fan

No. 1892—A newly perfected "Allvent" fan, an all purpose ventilating fan designed to provide any normal required amount of air changes without objectionable noises, has been announced. Features include a v-belt drive, aimed to make possible slower and quieter operation and higher efficiency with 1750 rpm stock motors, the maker states.



The three blade fan wheel is of new design and is said to supply or exhaust large air volumes. The fans are available in a range of ratings from 4070 to 23,000 cfm, the motor horsepowers running from 1/6 to 1 hp.—Autovent Fan & Blower Co., 1811-27 N. Kostner Ave., Chicago, Ill.

For your convenience in obtaining more information about any of this equipment, see coupon on page 130. Add the new products and companies listed here to your Directory Section which you received in your January, 1940, HEATING, PIPING AND AIR CONDITIONING and thus keep your records of sources of supply up to date throughout the year . . . Single asterisk (*) indicates equipment not listed in Directory Section; double asterisk (**) equipment and manufacturer not listed

A STUDY IN QUIET..

UNION MEMORIAL BLDG., University of Wisconsin, Madison, Wisc. Here, as on hundreds of other systems, Airacoustic Sheets keep ducts quiet. Basically mineral, they resist moisture and fire. Architects Corbett and McMurray specified more than 17,000 sq. ft. of Airacoustic Sheets.

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IN this new University of Wisconsin building, all the advantages of air conditioning are assured . . . all the nuisance and trouble of noisy ducts eliminated.

Architects Corbett and McMurray made sure the system will stay quiet by specifying J-M Airacoustic Sheets as duct linings. This modern material absorbs more than 70% of all sound in ducts. Its mineral structure provides effective resistance to fire-spread . . . gives full protection against the dangers of humidity. And because Airacoustic Sheets are lightweight and easy to apply, their installed cost is unusually low.

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ANY TYPE DUCT is quickly and economically lined with J-M Airacoustic Sheets. For this modern material is light in weight, easy to handle—installation is fast . . . costs are low.

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Use These 2, 3 and 4-Speed Motors for ECONOMY on Variable Speed Drives . . .

Year after year more engineers and contractors specify and use HOWELL Multi-Speed Motors — for driving fans, pumps, compressors, etc. They find that these 2, 3 or 4-speed motors meet a great many requirements without any sacrifice of results — *and the savings, as against expensive slip-ring motors with expensive variable speed control, are considerable.*

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★ ***Multi-speed motor shown above drives fan in air conditioning system — large pharmaceutical plant. This company (name upon request) INSISTS on HOWELL, as a result of over 20 years' experience with hundreds of HOWELL Motors of all types.***

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HOWELL makes all types of air-conditioning motors, ½ to 150 HP — a goodly share of them SPECIAL motors. If you have ANY drive problem, and want FAST ACTION, direct your inquiry our way. Even though special, we can produce your job immediately—NO DELAY. *At HOWELL, real service and finest quality go hand in hand.*

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Booklets, Reports and Papers

Transactions of Anthracite Conference

The Transactions of the Third Annual Anthracite Conference have been published in a 238 p., 6 x 9 in. paper covered book by Lehigh University, Bethlehem, Pa. The conference was held May 9 and 10.

Seventeen papers are included relating to the use of anthracite in many fields, such as its application to baking ovens, domestic stokers, central power stations, cupolas, and in semi-industrial stokers. There are also discussions on mineral wool from anthracite colliery refuse and anthracite ashes, chimneys and draft, filtering, anthracite research, applications of anthracite producer gas, ash handling equipment and standards for burning equipment.

A paper of particular interest covering radiant heating, was presented by B. H. Jennings, associate professor of mechanical engineering at Lehigh. This paper reviews the engineering fundamentals of this type of heating, gives information on its advantages and disadvantages, and presents a bibliography of 14 references.

Moisture Control and Building Construction

Bulletin No. 17 of the Engineering Experiment Station, University of Minnesota, Minneapolis, is entitled Methods of Moisture Control and Their Application to Building Construction, by Frank B. Rowley, Axel B. Algren and Clarence E. Lund. It is a 57 p., paper covered, 6 x 9 in. booklet. The contents include a general discussion of the problem, equipment, instruments and test results.

The bulletin brings the reader up to date on the comprehensive research program started in 1937 by the National Mineral Wool Association in coöperation with the University of Minnesota, the objects of which were (1) to determine the extent of condensation within modern buildings and with different methods of operation; (2) to measure the effectiveness of different types of construction; and (3) to find the limiting conditions under which various types of building designs may be used without excessive condensation and still retain the benefits of air conditioning and good building construction.

A number of papers on the work have been presented to the American Society of Heating and Ventilating Engineers and have appeared in the ASHVE Journal Section of HEATING, PIPING AND AIR CONDITIONING.

Ratings for Cast Iron Boilers

The Institute of Boiler and Radiator Manufacturers, 60 E. 42nd St., New York, N. Y., has issued a 23 p. booklet on IBR Ratings for Cast Iron boilers approved by the institute for various manufacturers.

The ratings cover boilers up to 20 in. grate width, and the institute's program for 1940 will cover the testing and rating of larger boilers.

Measurements of Ventilation

A paper on Measurements of the Ventilation of Dwellings by C. G. Warner appeared in the Journal of Hygiene, Vol. XL, No. 2, April 8, 1940. This journal is published in London, the United States agents being the University of Chicago Press.

The paper reviews methods of estimating air change by gas dilution, gives the author's observations in apartments and other dwellings, and discusses effects of various factors on the rate of air change—wind strength, wind direction, infiltration, room size, temperature difference between outside and inside, and humidity.

The rate of air change was determined in the tests by liberating a quantity of coal gas into the room and measuring the rate

of its disappearance by means of a "kathorometer." The hygienic significance of air change is discussed and various recommended standards of air supply are reviewed. Results of the inquiries show that in enclosed, flueless rooms the air supply is likely to be much below 600 cfh per occupant.

Book Reviews

Handbook on Hot Water Heating

This new handbook on hot water heating includes a great deal of engineering data and installation information which has been coördinated and simplified in a practical and usable form. It offers a thorough exposition of fundamental heating facts with many diagrams for the design and installation of forced circulation systems and indirect domestic water heating systems.

The book is divided into three main classifications: (1) indirect domestic water heating systems, (2) forced hot water heating systems, and (3) electrical controls. In addition there is a section devoted to tables of general information needed by the contractor, engineer and architect. Each of the main sections is divided into an outline of basic designing, illustrations, descriptions, and capacities of the equipment involved.

This 262 p. pocket size book, bound in leather finish covers, is published by Bell & Gossett Co., 3000 Wallace St., Chicago, Ill. It is being distributed by wholesalers to the trade on a special plan.

Design of Piping for Flexibility

[Design of Piping for Flexibility with Flex-Anal Charts, by E. A. Wert and S. Smith of The Detroit Edison Co. 1st ed. 1940. 80 pp. + picture section, 8½ x 11 in., spirally bound. Published by Blaw-Knox Co., Power Piping Div., 829 Beaver Ave., Pittsburgh, Pa. Available without charge to executives, engineers and others interested in piping design problems on request on business letterhead. Price, $3.00 to others.]

This book was compiled, after over 10 years of work on the part of the authors, with the idea of placing in the hands of the experienced piping designer a series of charts and simple formulas to enable the engineer or designer to obtain the stresses, forces, moments and deflections in piping designs of one, two and three plane structures. The method offered enables the work to be done in much less time than by previous available methods, according to the publishers.

The book is divided into 15 chapters and there are 36 plates and three tables of design data. Fundamentals of the problem and the method of design are outlined clearly and in detail. The charts are legibly produced in convenient sizes for use.

A pictorial section on the publisher's facilities for fabrication of high pressure, high temperature piping is appended.

Opportunities in Refrigeration

[The Next Great Industry, by L. K. Wright, chief instructor of refrigeration course, New York YMCA Trade and Technical School. 1st ed. 1939. 194 + ix pp., 5 x 7½ in., clothbound. Published by Funk & Wagnalls Co., New York, N. Y. Price, $1.50.]

This little book, one of the Kitson Careers Series, is devoted to opportunities in air conditioning and refrigeration. It includes interesting but rather general discussions of the scope of refrigeration, methods and means, discoveries and inventions, trade schools and technical courses, typical courses of study, service work and distributors' functions, elements of refrigeration, operation of a refrigeration machine, and air conditioning apparatus. There is also a 10 p. listing of books, magazines and schools, which (while not complete) is of some interest.

Only the summer cooling phase of air conditioning is considered in this work, and the discussion refers particularly to unit or packaged equipment.

AEROFUSE OUTLET

SELECTED FOR MODERN DRAFTING ROOM

THE design of this most modern of drafting rooms advanced in lighting, and in air conditioning to provide ideal working conditions, quite naturally includes the installation of the Aerofuse Outlet. This functionally superior air diffuser, is so simple in exterior design tha it harmonizes unobtrusively with any decorative scheme —and may be tastefully combined with practically any type of lighting fixture. And—all important—the Aerofuse Outlet sacrifices no part of its efficiency for its beauty. I provides 1. Maximum Air Mixture; 2. Rapid Temperatur Equalization; 3. Perfect Air Distribution; 4. Total Elimino tion of Drafts.

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A NEW LINE of WORTHINGTON ROTARY PUMPS

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THESE new compact herringbone gear rotary pumps are built for small capacity and low pressure requirements.

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- Excellent suction lift qualities
- Four-bearing construction . . . long pump life
- Force-feed lubrication . . . no grease cups
- High pump efficiency . . . low power consumption
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A smooth flow of liquid through these pumps maintains a steady discharge pressure. Standard motors of any make, up to 1750 r.p.m., can be used.

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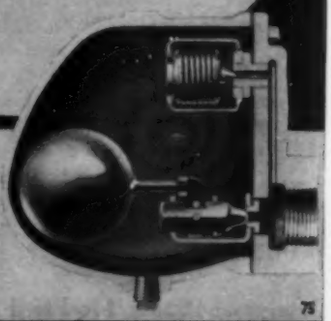
TRAPS

This is the best trap to use on heat exchangers and all equipment requiring accurate temperature control. Always used for dripping heating mains, for unit heaters and on all applications where a heavy load requires the instant removal of all condensation practically at the same temperature as that of the steam. Equipped with fully automatic air by-pass, actuated by a Sarco bellows. Air binding is impossible.



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Conventions and Expositions

American Association of Industrial Physicians and Surgeons: Annual meeting, June 4-7, Hotel Pennsylvania, New York, N. Y. Executive Secretary, Armour G. Park, 540 N. Michigan Ave., Chicago, Ill. Devoted to problems of industrial health in all their phases—medical, technical and hygienic—with particular stress on prevention and control of occupational hazards.

Stoker Manufacturers Association: Annual meeting, June 6-7, Homestead Hotel, Hot Springs, Va. Headquarters office, 307 N. Michigan Ave., Chicago, Ill.

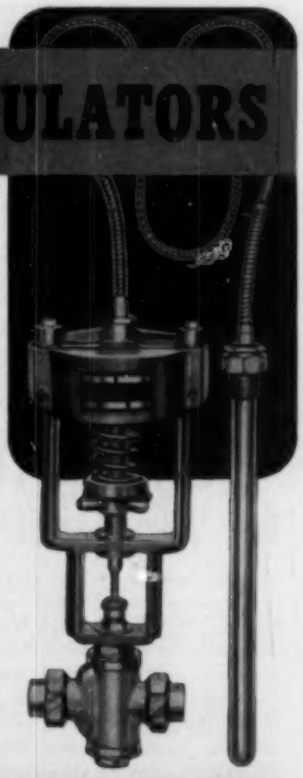
American Society of Refrigerating Engineers: Spring meeting, June 9-11, Skytop Lodge, Skytop, Pa. Secretary, David L. Fiske, 37 W. 39th St., New York, N. Y. Program includes papers on Refrigeration in the Chemical Industry, by D. H. Killeffer; Performance of Heat Exchangers, by David Crampton; Effect of Superheat on Compressor Capacity, by R. H. Tull; Distribution of Air, by Walter Grant; and The Problem of the Air Conditioning Sales Manager, by J. deB. Shepard.

Air Conditioning Show: June 14-22, Downtown Store and Assembly Hall, Commonwealth Edison Co., 72 W. Adams St., Chicago, Ill. Will include year 'round equipment, store coolers, room coolers, fans, etc.

American Society of Heating and Ventilating Engineers: Semi-annual meeting, June 17-19, Wardman Park Hotel, Washington, D. C. Secretary, A. V. Hutchinson, 51 Madison Ave., New York, N. Y.

American Society of Mechanical Engineers: Semi-annual meeting, with simultaneous sessions at the Hotel Pfister, Milwaukee, Wis., June 17-20, University of Michigan, Ann Arbor, Mich., June 20-21, and Berkeley-Carteret Hotel, Asbury Park, N. J., June 19-22. Headquarters office, 29 W. 39th St., New York, N. Y. Papers at Milwaukee sessions include Turbulence

TANK REGULATORS



The Sylphon No. 931 Regulator is practically the "Standard" for control of hot water storage tank temperatures.

Thousands are in use. Many installed more than 20 years ago are today performing just as efficiently as when new — proof of their lasting satisfaction.

Select Sylphon Regulators for your storage water heaters, install them and forget them.

Write for Bulletin LE-20, which describes this and many other Sylphon Regulators for control of service hot water, refrigeration and industrial processing.

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BALDOR MOTORS

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These motors are effectively fancooled, driving a constant stream of air over the entire exterior of the motor frame — an efficient, *non-clogging* cooling system.

Protected against dust, dirt, splash, flame, condensation and internal damage. Ball-bearing. Dynamically balanced.

THE MOTOR OF TOMORROW. Baldor Streamcooled Motors in redesigned and more compact N. E. M. A. dimension frames with 100% glass insulation.

Many other features explained in BALDOR Bulletin No. 202. Ask for it

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As modern as tomorrow — this attractive bar in the Greensburger Hotel, Greensburg, Pa., calls upon A-P Valves for dependable, accurate temperature control at all times.

Refrigeration requirements at the Greensburger, with temperatures ranging from +38° to 15° below zero, are efficiently maintained by these modern Willco Compressors — A-P Controlled.

A hotel's reputation is dependent upon the service of its table — Day in and day out, A-P Valves faithfully perform their duty in maintaining proper temperatures for the Greensburger's frozen food storage.

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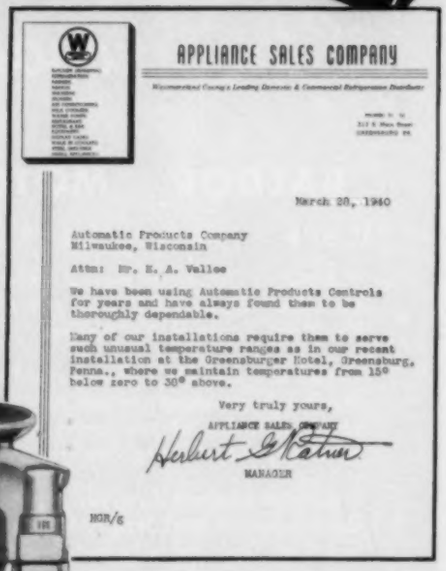
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March 28, 1940

Automatic Products Company
Milwaukee, Wisconsin

Attn: Mr. H. A. Valloe

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MANAGER

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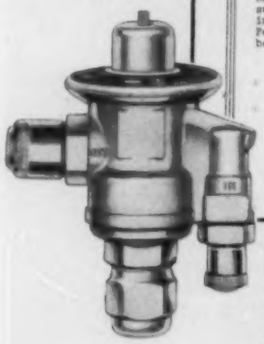

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and Energy Dissipation, by A. A. Kalinske; A Theory of Cavitation Flow in Centrifugal Pump Impellers, by Calvin A. Gongwer; The Employer Suggests Needed Improvements in Our System of Technical Education, by W. H. Carrier; Centrifugal Pump Efficiency Measurements—an Improved Technique, by R. W. Angus; A Study of Heat Insulation Problems in Steam Power Plants, by E. T. Cope and W. F. Kinney; Experience with Metals at High Temperatures, by A. E. White; Air Pollution Study—City of Chicago, by Osborn Monnett; Hard-Facing —A Process for the Mechanical Engineer, by E. E. LeVan. Papers at Ann Arbor meeting include Flow Through Granular Media, by L. P. Hatch; and Chart of Air-Vapor Mixture Properties at Different Pressures, by R. C. Binder. Oil and gas power sessions to be held at Asbury Park.

National Association of Building Owners and Managers: Annual convention, June 17-20, Commodore Hotel, New York, N. Y. Headquarters office, 134 S. La Salle St., Chicago, Ill.

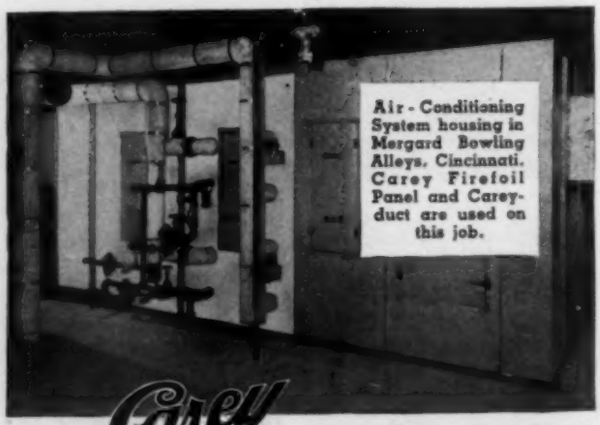
American Society for Testing Materials: Annual meeting, June 24-28, Chalfonte-Haddon Hall, Atlantic City, N. J. Headquarters office, 260 S. Broad St., Philadelphia, Pa.

Public Housing Study Tour: July 15-August 15, covering 11 states and District of Columbia. Sponsored by National Public Housing Conference, 122 E. 22nd St., New York, N. Y.

Power Show: 14th National Exposition of Power and Mechanical Engineering, December 2-7, Grand Central Palace, New York, N. Y. Under management of International Exposition Co., Grand Central Palace, New York, N. Y.

American Chemical Exposition: December 11-15, Stevens Hotel, Chicago, Ill. Under auspices of Chicago section, American Chemical Society. Exposition manager, Marcus W. Hinson, 110 N. Franklin St., Chicago, Ill.

Refrigeration and Air Conditioning Exhibition: January 13-16, Stevens Hotel, Chicago, Ill. Sponsored by Refrigeration Equipment Manufacturers Association, R. M. McClure, Executive Secretary, 111 W. Washington St., Chicago, Ill.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Recent Trade Literature

For your convenience in obtaining copies of these bulletins, see coupon on page 130. If you write direct to the manufacturer, describe carefully what literature you want, as the number given first in each item is for use only when sending your request to HEATING, PIPING AND AIR CONDITIONING.

No. 3533. AIR DISTRIBUTORS: Charles Demuth & Sons, 112-07 New York Blvd., Jamaica, N. Y. 4 p. bulletin on new air distributor for air conditioning systems and leaflet giving installation instructions.

No. 3534. ALLOYS: Climax Molybdenum Co., 500 Fifth Ave., New York, N. Y. Issue of "The Moly Matrix" (Vol. 7, No. 4) including an article on use of molybdenum cast iron for high pressure pipe line valves.

No. 3535. BEARINGS: Fafnir Bearing Co., 37 Booth St., New Britain, Conn. 130 p. condensed catalog (35A) covering the manufacturer's complete line of radial, thrust, precision, self-aligning and sealed bearings and housed transmission units, with data on dimensions, load ratings, types and sizes.

No. 3536. BOILER AND TANK ACCESSORIES: Steel Improvement & Forge Co., 960 Addison Rd., Cleveland, Ohio. 40 p. catalog (10) on "Diamond-S" accessories for fired and unfired pressure vessels, including sections of technical data and general information. Manhole and handhole covers, welding fittings, water column ells, forged flanges, and gaskets are illustrated and described.

No. 3537. COAL ACCELERATORS: Stephens-Adamson Mfg. Co., Aurora, Ill. Leaflet describing coal accelerator for use in unloading high moisture content coal, frozen coal and moist slack heavy in "bug dust," describing operation and construction.

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No. 3538. COMBUSTION CONTROL: Republic Flow Meters Co., 2240 Diversey Pkwy., Chicago, Ill. 94 p. data book (S-21) on "Republic-Smoot" automatic combustion control for all sizes of boilers, all types of fuel firing and all load conditions. A number of installation reports illustrated with large diagrams and presenting performance data and evidence of benefits are included.

No. 3539. CONTROLS: Automatic Control Co., 2590 University Ave., St. Paul, Minn. 12 p. catalog section (4) on "Selectrols," single float operated, multiple circuit program controls for sewage pumps and valves. Construction data, information on selection and specifications are included.

No. 3540. CONVECTORS: Tuttle & Bailey, Inc., Corbin Ave., New Britain, Conn. 12 p. catalog (C4) on copper convectors with information on their advantages and cost, construction details, dimensions, selection, list prices and capacities.

No. 3541. DEAERATING HEATERS: Cochrane Corp., 3161 N. 17th St., Philadelphia, Pa. 12 p. booklet giving a pictorial presentation of the manufacturer's deaerating heaters, explaining in an interesting manner details of construction.

No. 3542. DEHYDRATION: Highside Chemicals Co., 195 Verona Ave., Newark, N. J. 12 p. bulletin written for practical refrigeration men on the use of the manufacturer's dehydrant and neutralizer for refrigerating systems.

No. 3543. FANS: Truflo Fan Co., Harmony, Pa. 4 p. bulletin (240) on "Truflo" propeller wall fans, automatic shutters, penthouse fans and roof ventilating fans, with specifications and dimension data.

No. 3544. FIN COILS: Rempe Co., 340 N. Sacramento Blvd., Chicago, Ill. 76 p. catalog (107) on fin coils for various purposes, giving complete information about them and their prices and capacities.

No. 3545. FLEXIBLE METAL HOSE: Chicago Metal

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Hose Corp., Maywood, Ill. 38 p. catalog (G-21) on "Rex-Weld" and "Rex-Tube" flexible metal hose, stainless steel flexible connections, stainless steel bellows, diesel exhaust hose, and fuel and oil hose.

No. 3546. HEATING AND COOLING SURFACE: John J. Nesbitt, Inc., State Rd. and Rhawn St., Philadelphia, Pa. 24 p. bulletin on "Series W" water type surface for cooling, dehumidifying and heating, presenting a complete technical discussion on selection of surface for cooling and dehumidification and for heating with forced hot water, giving examples, describing construction features and presenting physical data, surface characteristics, a surface temperature chart, over-all heat transfer coefficients, a logarithmic mean difference chart, piping diagrams, etc.

No. 3547. LUBRICATION: Texas Co., 135 E. 42nd St., New York, N. Y. Issue of "Lubrication" (Vol. 26, No. 4) devoted to electric motor bearings and their protection by lubrication.

No. 3548. MOTORS: General Electric Co., 1 River Rd., Schenectady, N. Y. 4 p. bulletin (GEA-3307) on self-starting synchronous inductor motors for indicating and recording instruments.

No. 3549. MOTORS: General Electric Co., 1 River Rd., Schenectady, N. Y. 2 p. leaflet (GEA-3352) on fractional horsepower sump pump motors with built-in float switch and automatic reset thermal overload protection.

No. 3550. MOTORS: Leland Electric Co., 1501 Webster St., Dayton, Ohio. 4 p. folder on two speed motors for blower applications and their advantages. Also a 4 p. leaflet featuring a chart showing typical applications for various motor types.

No. 3551. MOTORS: U. S. Electrical Motors, Inc., 200 E. Slauson Ave., Los Angeles, Calif. 8 p. bulletin on design and

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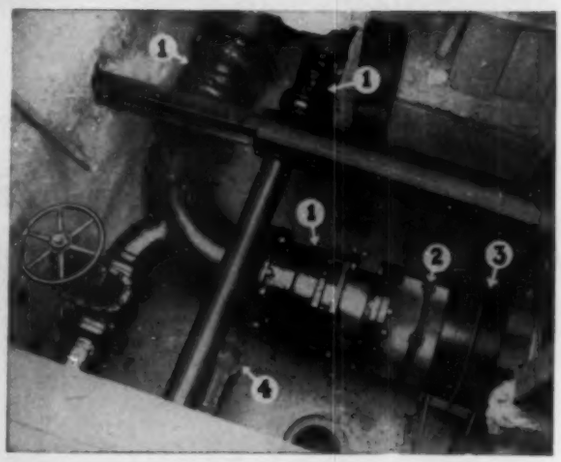

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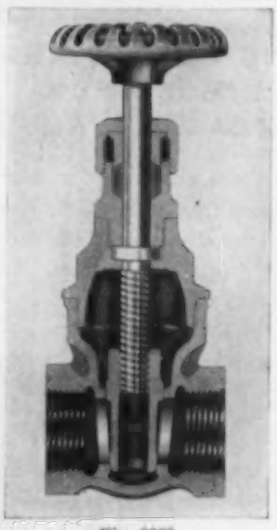

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operation of the manufacturer's single phase motors, dealing with mechanical and electrical characteristics of single phase, capacitor start motors.

No. 3552. OIL BURNERS: Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Leaflet (9HC-0628) describing three new "Spiralaire" oil burners for large steam, hot water or warm air heating systems in commercial and industrial buildings and homes.

No. 3553. PROPELLER FAN BLADES: Torrington Mfg. Co., 70 Franklin St., Torrington, Conn. Looseleaf catalog on three and four blade free air type propeller fan blades; two and four blade pressure type fan blades; attic types; and small diameter blades. An informative introductory section on selecting a propeller fan blade gives instructions for selection and explains test codes and fan laws. Each blade is illustrated and described in detail, with complete specifications and performance ratings for both free air delivery and pressure performance.

No. 3554. PURGERS: Armstrong Machine Works, 874 Maple St., Three Rivers, Mich. 8 p. engineering bulletin on cutting refrigeration costs by the use of foul gas purgers, with information on why automatic purgers should be used, how to tell when a purger is needed, how much gas is lost from purgers, and giving data on installation, operation, selection and advantages.

No. 3555. RADIATORS: Crane Co., 836 S. Michigan Ave., Chicago, Ill. 12 p. bulletin on "Compac" radiators for recess or free standing installations and designed to occupy minimum space. Dimensions and ratings are given.

No. 3556. REFRIGERATION AND AIR CONDITIONING PARTS: Airo Supply Co., 2726 N. Ashland Ave., Chicago, Ill. 96 p. catalog and buyers' guide (40) of refrigeration

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No. 3557. ROOM VENTILATORS: Carrier Corp., 302 S. Geddes St., Syracuse, N. Y. 4 p. folder on the benefits obtainable by the use of room ventilators in bedrooms, living rooms, offices, etc.

No. 3558. RUBBER PUTTY: B. F. Goodrich Co., 548 S. Main St., Akron, Ohio. 2 p. catalog section on "Plastikon" rubber putty adaptable to many uses in building and industry and of interest to the air conditioning field in maintaining air- and moisture-tight seals.

No. 3559. STRAINERS: Wright Austin Co., 315 W. Woodbridge St., Detroit, Mich. 2 p. circular (295) on "Easy-clean" strainers for steam, air, gas, oil or water.

No. 3560. SURFACE CONDENSERS: Ingersoll-Rand Co., 11 Broadway, New York, N. Y. 8 p. bulletin (Form 2622) on cross flow surface condensers in sizes ranging from 200 to 1500 kw, showing typical installations, cross-sectional views and structural details.

No. 3561. VALVES: Crane Co., 836 S. Michigan Ave., Chicago, Ill. 306 p. catalog (40-S) devoted exclusively to steel valves and fittings and kindred steel specialties and accessories, containing a great deal of engineering data pertaining to high pressure-temperature piping problems. A novel method of indexing the catalog makes it easy to turn quickly to the section wanted. Also, a 12 p. bulletin on "tailor-made" small steel valves, describing their manufacture and design, pointing out that they are designed for easy maintenance and giving list prices and dimensions of the various types with pressure-temperature ratings.

No. 3562. VIBRATION CONTROL: Felters Co., Inc., 210 South St., Boston, Mass. 24 p. booklet on the use of "Unisorb"

ELECTRIC HEAT supplants boilers and cuts cost of process steam

During summer months, this plant shuts down boilers and makes steam for kettles with a few pipe fittings and the

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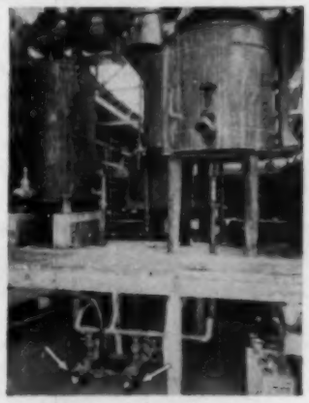

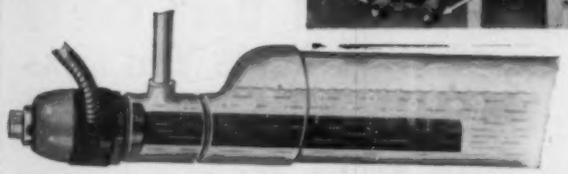

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No. 3563. WATER CHILLERS AND CONDENSERS: Richmond Engineering Co., Inc., 7th and Hospital Sts., Richmond, Va. 6 p. bulletin on "Reco" cross draft "Freon" water chillers and condensers of the shell and tube type; 6 p. bulletin on "whirlpool action" dry expansion "Freon" water chillers; and 4 p. bulletin on pressure tank water coolers. Information on construction, selection and specifications is included.

No. 3564. WELDED OUTLETS FOR PIPING: Bonney Forge & Tool Works, Tilghman St. and Meadow St., Allentown, Pa. 20 p. bulletin (WT-29) illustrating and describing "Weld-Olets," "ThredOlets" and "Socket-End WeldOlets"—welded outlets for piping. Various types of outlets they will make, how they are installed and their advantage in reducing turbulence and friction are illustrated and described.

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